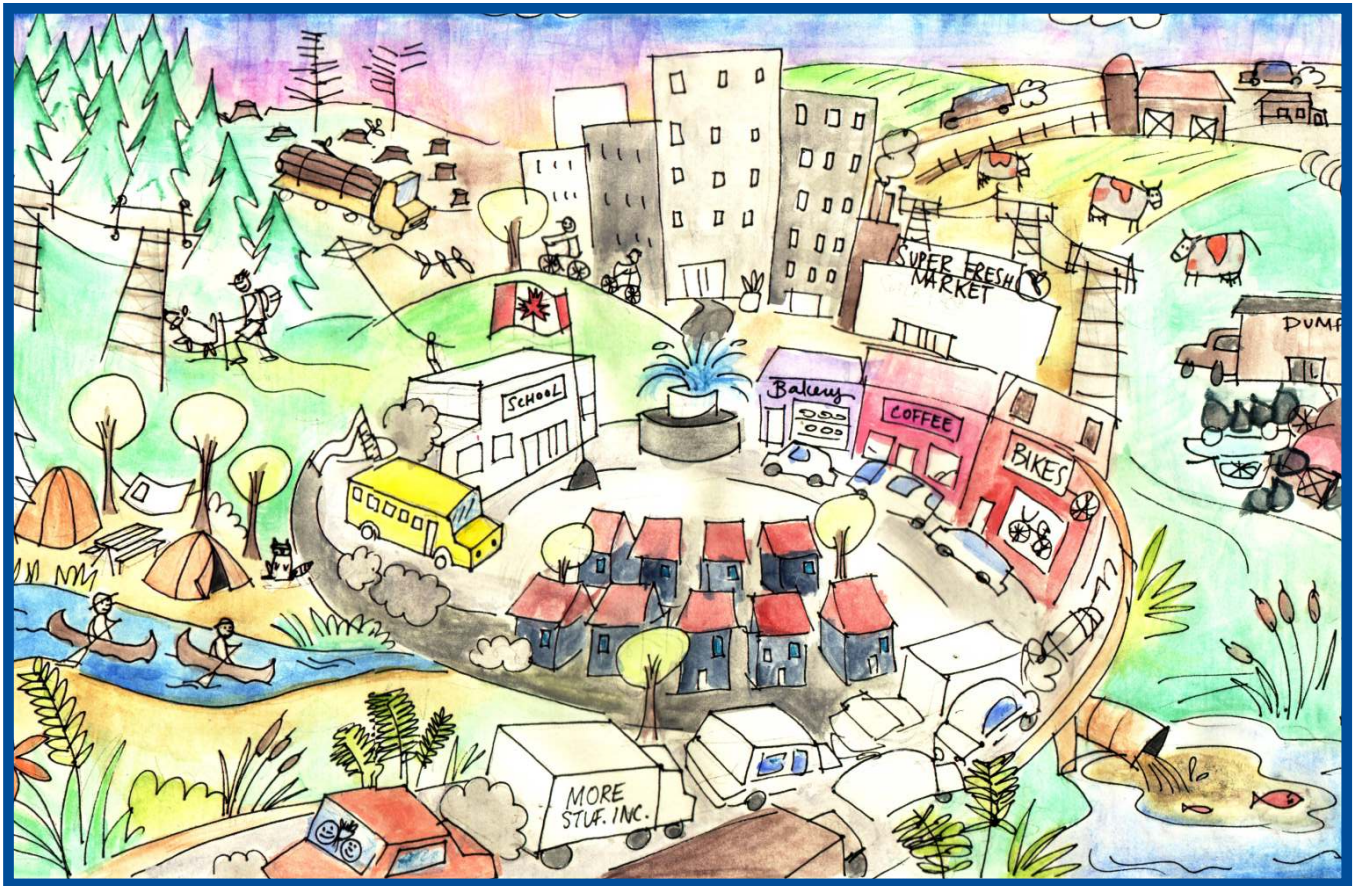


Heat in the Environment:

Grade 7 Integrated Unit

November 2009



Heat in the Environment:
Grade 7 Integrated Unit

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This document has been reviewed for equity.

Acknowledgements

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Introduction

This resource was created in conjunction with a science and technology kit for the Heat in the Environment unit in Grade 7 Science and Technology: Understanding Earth and Space Systems. It was written by the EcoSchools department with support from science teachers, science and technology Instructional Leaders, and with the contribution of some stakeholders in science education and environmental literacy. This resource helps students learn about heat in the environment through the use of technology and activities developed by DataHarvest Education. The resource also offers additional readings and hands-on activities, and a guide for a field trip to Exhibition Place, which, with support from the YESS! Program of the Toronto Renewable Energy Co-operative, helps to foster the development of knowledge, attitudes, and skills that can lead to new behaviours, new designs, and new, lower-impact ways of meeting our energy needs.

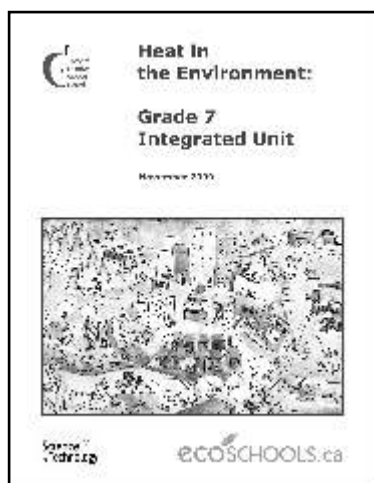
The activities comprising this unit involve both cross-curricular and integrated learning. For example, students use language skills in their reading and communication throughout the unit. The activities also provide links to expectations in subject areas such as math, geography, and other science strands.

Understanding heat is crucial for students' future success in science and for heightening their awareness of the ways that heat affects our world. This resource, in combination with the accompanying Heat in the Environment Kit, can help teachers make a timely contribution to students' ecological literacy by showing the connections between energy use, energy transfer, heat loss, and climate change.

The Heat in the Environment Kit is a powerful means to help students develop their hands-on science and technology skills. It is hoped that this kit will:

- provide expanded opportunities for Grade 7 students to engage in hands-on learning, and with links to action-oriented projects in their schools
- widen the use of best-practice strategies at the middle school level
- provide teachers with theoretical and practical support in the development of Grade 7 curriculum that integrates science and technology, language arts, mathematics, geography, and EcoSchools

The topic of Heat is difficult to teach because so many of the processes related to heat are invisible. To address this challenge, the Grade 7 Heat in the Environment kit includes two special pieces of equipment: an infrared sensor that permits teachers and students to have fun measuring and exploring infrared radiation, and an infrared thermometer that allows instantaneous temperature measurement of a surface that is out of reach. These technical capacities allow students to explore more deeply and concretely the nature of energy transfer, both inside and outside the classroom.



Tell your students that heat is everywhere.

Then show them the cover of this resource. Ask them to describe what they see and to connect their observations to heat.

At first this may feel too open a task. After an initial discussion, ground students' ideas by reminding them that wherever the sun shines, we have heat; wherever we burn fuel, we have heat.

Continue the discussion by asking students to use the cover drawing as the starting point to talk about heat in contrasting settings: night and day, built and natural environment; summer and winter; and urban and rural.

Students will now be ready to undertake a study of Heat in the Environment.

Getting Started

Ecological Literacy

Ecological literacy is about seeing beneath and above what we humans are creating—beneath to reveal the impacts that lie out of sight and out of mind; above to go beyond politics, sports, wars, and trade agreements. Ecological literacy involves understanding that the Earth behaves as a single ecological system. It is profoundly affected by human activity. As with all systems, a disruption in one part has an impact somewhere else in the system. Over time, local actions of people and economies everywhere do have global consequences. We're all in this together.

The Ontario Ministry of Education's *Shaping Our Schools, Shaping Our Future: Environmental Education in Ontario Schools* (June 2007) calls for greater attention to the role that schools can play in preparing students to be aware, informed, and empowered citizens who can help shape the global environment. The report says “environmental education is education about the environment, for the environment, and in the environment” (p. 6). EcoSchools' goal is to make this triad part of the everyday language of lesson planning.

Education *in* the Environment

Education in the environment means making use of the environment as a context and a setting. It denotes direct observation and experiential learning. For the topic of heat, students connect their studies of heat to their homes and classrooms, their school grounds, the City of Toronto, and to the global challenge of reducing the greenhouse effect. It is important for students to understand how they can make a difference here and now by paying attention to issues such as heat loss in their homes and schools.

Education *about* the Environment

At the core of learning about the environment is the study of how land, air, and water ecosystems work, and the knowledge that human well-being is dependent on ecosystem health. Climate change is a consequence of our soaring increase in burning fossil fuels to supply our energy needs; it provides the context within which we study heat and learn about the interconnections between human activity and the environment.

Education *for* the Environment

Education for the environment helps students develop skills to examine human impact on the environment; research ways to reduce that impact through conservation, adaptation, and innovation; and advocate for change and actions that will reduce individual and collective ecological footprints.

Structure of the Resource

To mirror the three elements of environmental education, this resource is structured in three parts: Education *in*, *about*, and *for* the Environment.

- Education *in* the Environment has four activities, including a series of investigations that introduce the EasySense probes and Data Logger (part of the kit) and get students thinking about heat transfer and heat loss. Students move outside to engage in a study of heat as it relates to the classroom and school grounds. That activity is followed by a study of a variety of initiatives taking place at Toronto's Exhibition Place, including The Toronto Renewable Energy Co-operative's Youth Energy and Sustainability (YESS!) program. A trip to Exhibition Place can effectively raise student awareness of critical energy issues.
- Education *about* the Environment features seven activities that explore heat in the context of climate change. Students study climate change, urban heat islands, embedded energy in the life cycle of products, and the potential for wind power from Canadian winds.
- Education *for* the Environment has four activities that ask students to explore the impact they and their school can have on the environment. They use the EasySense probes and Data Logger in their investigations of energy conservation in the classroom and at home.

Each lesson plan provides:

- an overview of the activity
- curriculum expectations addressed
- a list of required materials and BLMs
- planning notes
- the teaching/learning strategies
- BLMs, which appear directly after each lesson plan

What's in the Kit?

The Heat in the Environment Kit contains the following items, each of which are described in more detail in the next few pages.

- Compact Disc – EcoSchools Climate Change Powerpoint Presentation
- Posters – four laminated posters
- Scientific Probes – Q5 EasySense Data Logger Set (includes an infrared sensor) and an Infrared Thermometer
- Equipment – Glass Exploration Kit and Heat Lamp

► COMPONENT 1:

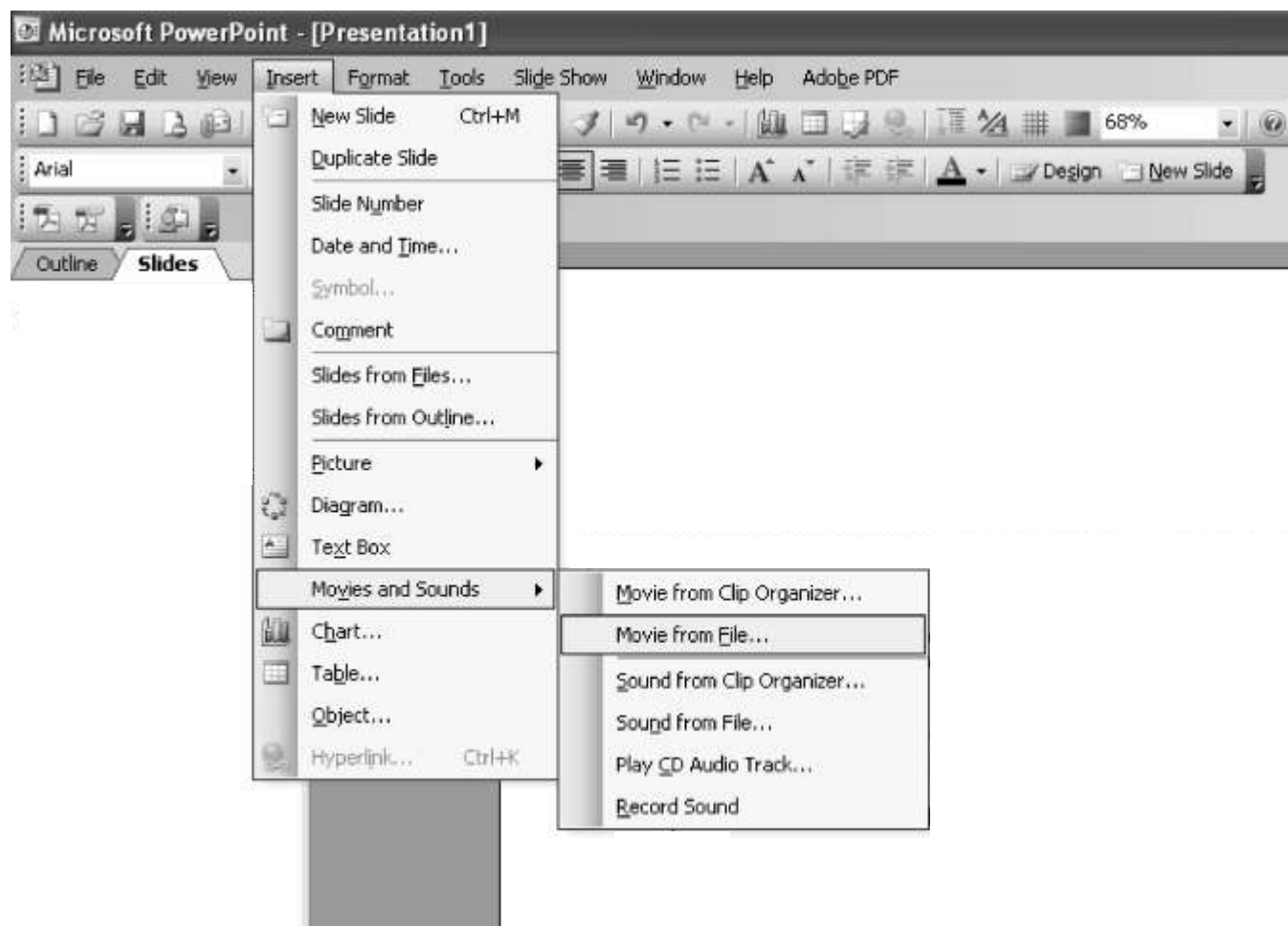
EcoSchools Climate Change Powerpoint Presentation CD

This presentation can be used to introduce students to the Heat in the Environment unit. It is highly visual and includes several engaging animations. The presentation connects climate change to some of the basic science of carbon cycles and can be used to underscore the imperative to take action.

How the Presentation Works

Notes for each slide are embedded in the presentation. If you wish to preview these notes before students see the presentation, you can do so by selecting the Notes option within the View menu.

If you want to run the presentation from your hard drive, you will have to create a folder called Grade 7 Heat in the Environment, and then insert the animations into the appropriate slides of the Powerpoint file using the Movie from File option of the Insert menu. See the steps in the screen capture, following.



► COMPONENT 2: Laminated Posters

The Story of Stuff

The Story of Stuff project was sponsored by Tides Foundation and Funders Workgroup for Sustainable Production and Consumption. Narrator Annie Leonard presents a 20-minute, fast-paced video, with animation, that details six stages of production of goods and appeals for a more sustainable approach. The video is web-based and free; it was first released online in December 2007. Note that there is also an international web page that offers the video with subtitles for 10 different languages. See:

- <http://www.storyofstuff.com/>
- <http://www.storyofstuff.com/international/>

Temperature Map of Southern Ontario

This remarkable map illustrates the “urban heat island” effect—urban microclimates that are significantly warmer than their surrounding rural areas. Satellites in space can use infrared sensors to identify cities as small as Cambridge, Ontario, because they are at a higher temperature than their surroundings. This temperature map is used in Activity 2.4: The Urban Heat Island Effect, on page 87.

Life Cycles Posters: Cell Phone, Soccer Ball, CD / DVD

These visually appealing, laminated posters illustrate the six to seven stages in the life of a product: extraction of natural resources; processing; shipping; manufacturing; transportation; use; and, finally, disposal. Emphasized in the posters is the fact that, at each stage, energy and water are used and waste heat is produced. The posters work well with *The Story of Stuff* (see the sidebar for more information). The posters can be used in various ways:

- as exemplars for student-generated life cycle posters
- as reading assignments; students can learn about the interconnectedness and complexity of production systems
- to emphasize the actual value and nature of the goods that we may take for granted; students could keep track of their own consumption of goods over a period of time
- as starting points for social studies research; students could trace the stages for particular goods (Canadian exports and/or imports)
- as starting points for writing or media literacy activities—journal; letter to the editor; video storyboard; public service announcement; political cartoon

These life cycle posters are used in Activity 2.6: Life Cycle Analysis: Embedded Energy on page 99.

► COMPONENT 3: Scientific Probes

There are two types of scientific probes included in the Kit: the Q5 EasySense Data Logger (which has built-in sensors, as well as two inputs for external temperature and infrared sensors) and an infrared thermometer. Both these probes are explained in detail in the next few pages, as well as in the product manuals and activity booklet that are included in the Data Logger set.

Science probes such as these are useful for many reasons:

- They permit measurement of quantities that can't be measured easily in any other way.
- They permit remote recording of data that can be triggered either manually or automatically. This allows for investigations that can be run at night or on weekends, when the school is closed.
- Recorded measurements are very quickly displayed in meaningful charts and graphs, providing more opportunity for students to interpret experimental data and better comprehend fundamental science concepts.
- The calculation time saved enables students to repeat investigations or spend that time in more educationally beneficial ways, such as discussing their results.
- The technology is more accurate and precise than conventional measuring tools. For example, a temperature probe can measure to 0.1 of a degree Celsius.
- Many more quantities can be measured simultaneously and therefore investigations move more quickly to the analysis and connection-making stage.
- Students are exposed to the same type of tools that working scientists use in their research laboratories.

1. Data Harvest Q5 EasySense Data Logger Set:

The Kit within the Kit!

The Q5 is a data logger from Data Harvest Educational—an educational company founded by teachers and specializing in probe technologies for Grades K–12. The Q5 is a rugged, easy-to-use data logger featuring five built-in sensors (sound, light, temperature, humidity, and air pressure). In addition to the five internal sensors, there are two inputs for connecting additional sensors. One additional sensor included in the kit is an infrared sensor that measures power per unit area (watts/m^2). The software allows data to be displayed in real time, or to be downloaded from the Q5 data logger when it is used in remote mode.

The complete data logger set includes the following. More detail about using the data logger appears in the manual that comes with the set, as well as on pages 11 to 15 of this resource.

- EasySense Q5 Sensing Science software for Windows
- Q5 data logger (with 5 internal sensors)
- Q5 data logger USB cable
- 2 plug-in temperature sensors
- 1 plug-in infrared sensor and an 8-pin DIN cable
- AC power supply
- Sensor cables
- Data Harvest *EasySense Q3 and Q5 User Manual*
- Data Harvest *Primary Curriculum Activities for EasySense*
- Data Harvest *EasySense Quick Start Guide*

The sensors and data logger are used in the following activities:

- Activity 1.1 Introducing the Unit and the EasySense Data Logger Set
- Activity 1.2 Hot Stuff: Mapping Your Face
- Activity 1.3 Mapping the Classroom and School Ground
- Activity 2.3 Trapping Energy: Building a Solar Oven
- Activity 2.5 Surfaces: Metal Foils
- Activity 3.1 Why Insulate Houses?
- Activity 3.2 Energy Conservation in the Classroom

2. Infrared Thermometer

The second scientific probe included in the Heat in the Environment Kit, along with the Q5 data logger, is an infrared thermometer. The infrared thermometer in the kit (IR) is a non-contact thermometer that allows users to quickly and conveniently measure the surface temperature of objects without physically touching the objects. You simply aim, pull the trigger, and read the temperature on the LCD display.

The IR thermometer can safely measure hot, hazardous, or hard-to-reach surfaces without contaminating or damaging the object. Regular contact thermometers are difficult to use in these situations because of access, shape, and range of measurement. With IR thermometers, the temperature of very hot objects such as car engines, furnaces, and light bulbs can be measured. Another advantage of infrared thermometers is their ability to provide several readings per second, unlike contact methods, in which each measurement can take several minutes.

The distance-to-spot ratio for the thermometer in the kit is 6:1. This means that the distance from the surface will always be six times the size as the diameter of circle of the collection area. You can read more about this ratio in the “Infrared Thermometers: A Quick Review” section, on page 15.

The infrared thermometers and temperature probes are used in the following activities:

- | | |
|--------------|--|
| Activity 1.1 | Introducing the Unit and the EasySense Data Logger Set |
| Activity 1.2 | Hot Stuff: Mapping Your Face |
| Activity 1.3 | Mapping the Classroom and School Ground |
| Activity 2.3 | Trapping Energy: Building a Solar Oven |
| Activity 2.5 | Surfaces: Metal Foils |
| Activity 3.1 | Why Insulate Houses? |

► COMPONENT 4: Other Equipment

1. Glass Exploration Kit

- 5 10 cm x 10 cm (4" x 4") pieces of coated glass
- wooden board with grooves for the glass
- tealight candles as heat sources

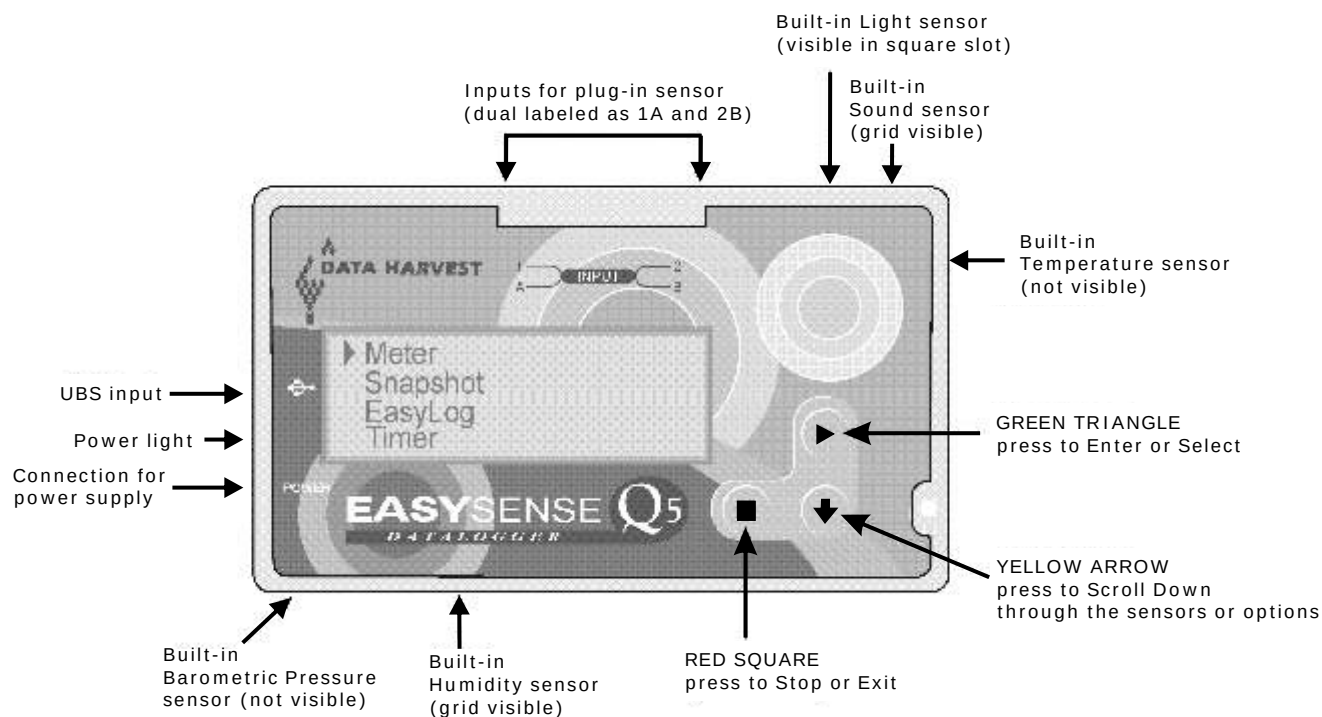
This equipment is used in Activity 3.2 Energy Conservation in the Classroom.

2. Heat Lamp

A lamp (an incandescent bulb) with an attached clamp is provided for use with the infrared sensor and the infrared thermometer.

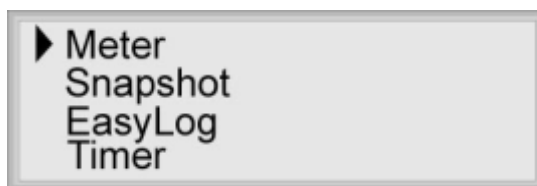
Using the Q5 EasySense Data Logger

The following diagram outlines the features of the Q5 EasySense data logger.



Data can be collected with this instrument in the same way we use any digital measuring instrument. Looking at the front of the Q5 data logger, you'll notice that there are three buttons on the lower right.

When the green button is pressed once, the LCD displays four modes. Select the Meter option by pressing the green button a second time.



In Meter mode, students can measure five different quantities. Simply use the Q5 data logger in this mode, read the LCD screen, and record the data on paper. The readings for the internal sensors will be displayed in the following order: sound, light, temperature, pressure, and humidity. On the LCD display, the sensor's value and units will be displayed, but not its name. They are numbered from 3 to 7, and appear as listed below. Numbers 1 and 2 are reserved for the plug-in sensors.

- 3) 46.7 dBA (sound)
- 4) 245 lx (light)
- 5) 25.2 °C (temperature)
- 6) 101.0 kPa (pressure)

You'll need to scroll down one line to see humidity, which will be displayed as

- 7) 45.6 RH (humidity)

Plug-in Sensors

Each unit comes with two plug-in temperature sensors and an infrared sensor. The temperature sensors have a stainless steel tube on one end and a 3-foot (1-m) cable with a DIN-type connector on the other end. When plugged in to the inputs at the top of the data logger, the temperature sensor is automatically identified and ready to take measurements. The infrared sensor has also been added to the Q5 set. It connects in the same way as a temperature sensor. Choose Input 1A or 2B. (For detailed technical information on the infrared sensor, read the infrared sensor manual in the kit's binder.)

Additional Data Collection using a Computer

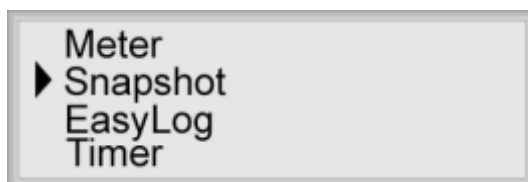
The Q5 data logger features two more sophisticated ways of obtaining data, when it is connected to a computer. Both the Snapshot mode (discrete data collection) and the EasyLog mode (continuous data collection) store the data, which can then be retrieved only by connecting the Q5 to a computer. Data acquired using the EasyLog mode can be retrieved by uploading it and using the EasySense software for graphing.

Snapshot Mode

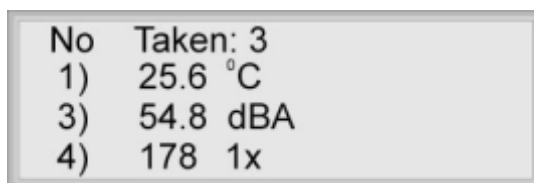
Snapshot data collected remotely cannot be viewed on the LCD screen. To see the recorded measurements, you must upload the data to a computer. See the EasySense manual, pages 47–48, for information on retrieving remote data.

Tip: It is a good idea to write down where and what was being measured for each “snap.” This way you’ll be able to identify the values when uploaded to a computer. Notice how the Q5 keeps track of how many measurements have been recorded.

- Press the yellow arrow ▼ to Scroll Down the menu list. Select the Snapshot option. In this mode you can record measurements by pressing the green Enter button. ►



- Each time the Enter button is pressed, a single value for all sensors (internal as well as plug-in) will be recorded—like taking a “snapshot.” Each additional press of the Enter button will add measurements to the data set. Press the Enter button several times.
- The Q5 will always record readings from all sensors. The software will allow you to quickly filter out the data that is of particular interest.



No	Taken: 3
1)	25.6 °C
3)	54.8 dBA
4)	178 1x

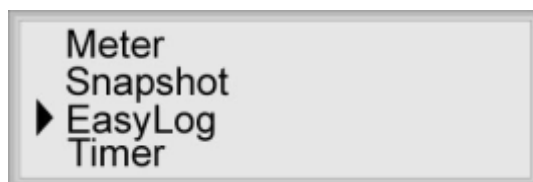
- Press the red stop button ■ to end the recording. The Q5 can store up to four separate recordings (data sets). There is no practical limit as to how many sensor measurements can be stored within each data set. However, when four data sets have been stored, the next saved data set will automatically overwrite the oldest data set.

EasyLog Mode

Retrieving data collected by EasyLog is explained on pages 8 to 9 of the EasySense Q3 and Q5 manual. In the EasyLog mode, the Q5 will continuously sample measurements for as long as you choose. As with the Snapshot option, all sensors will be recorded. In the software you'll have the option to filter out the desired data.

Tip: As data collection begins immediately in EasyLog mode, make sure the investigation is ready to go before hitting the Enter button.

In the main menu press the Yellow button ▼ to scroll down to EasyLog.



Pressing the green Enter button ► will instantly cause the Q5 to sample measurements at an initial rate of 40 samples per second for each sensor. At various points the Q5 will automatically reduce its sampling rate to avoid collecting an excess of data.

Press the Enter Button to see the status of the current recording (start time and date, sampling interval, and number of samples). Press the Enter button again to return to the previous screen.

Tip: Make sure that the surface of your target is larger than the collection area. The smaller the target, the closer you should be to it.

Understanding the Infrared Sensor

The infrared probe measures in two different units, across three different ranges.

Radiance 0 - 30W/m² sr -1, Resolution: 0.02W/m² sr -1

Radiance 0 - 300W/m² sr -, Resolution: 0.2W/m² sr-1

Radiance 0 - 3000W/m² sr , Resolution: 2W/m² sr -1

Irradiance 0 - 20W/m², Resolution: 0.01W/m²

Irradiance 0 - 200W/m², Resolution: 0.1W/m²

Irradiance 0 - 2000W/m² , Resolution: 1W/m²

If you want to see how a warm cup of water cools down, then use the second irradiance range (Irradiance 0 - 200W/m², Resolution: 0.1W/m²). If you want to measure a 150W light bulb at various distances, then the third irradiance range (Irradiance 0 - 2000W/m² , Resolution: 1W/m²) will be needed.

Safety

Never bring the infrared sensor closer than 30 cm to a heat source.

Selecting the Sensor Range

The infrared probe has more than one range. The range can be altered either on the data logger itself, or through the EasySense software. Once selected, EasySense Q will use this range or units (until they are reselected).

In the main menu, hold down the red square (Stop) button and then the yellow arrow (Scroll) button and keep them both held down for 2 seconds. The display will alter to show the System menu, i.e., Battery Level, Set Sensor Range, and Factory reset.

Use the yellow arrow to scroll the cursor until it is pointing at Set Sensor Range. Press the green triangle button to select.

Use the yellow arrow button to scroll the cursor until it is pointing to the relevant sensor, i.e., the internal light sensor or the Smart Q Sensor connected to external 1A or 2B. Press the green triangle (Enter) to select. An asterisk (*) will indicate the currently selected range.

Use the yellow arrow to scroll the cursor down until it is pointing at the required range. Press the green triangle (Enter) to select. The asterisk will move to indicate the selected range. Press the red square (Stop) to return to the system menu and then again to return to the main menu.

Summary of the Q5 Internal Sensors

Sensor number	Sensor Name	Name of Metric Unit	Unit Symbol	Range	Option to Change Range?
1 A	Input A				Depends*
2 B	Input B				Depends*
3	Sound	Decibels	dBA	40–110 dBA	No
4	Light	Light level in “lux”	lx	0–1000 lx 0–100 000 lx	Yes
5	Temperature (internal)	Degrees Celsius	°C	-30–110°C	No
6	Barometric pressure	Kilopascals	kPa	0–110 kPa	No
7	Relative humidity	Percent	%	0–100%	No

*If the sensor has ranges, then there will be an option to change the range. For example, the infrared sensor has three ranges.

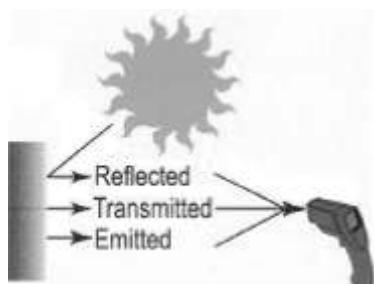
Infrared Thermometers: A Quick Review

1. How do infrared thermometers work?

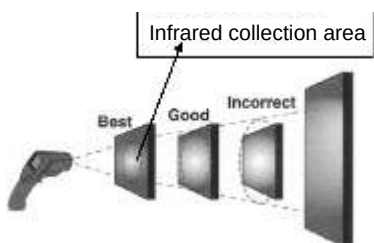
All objects emit infrared energy. The hotter an object is, the more active its molecules are, and the more infrared energy it emits. An infrared thermometer houses optics that collect the radiant infrared energy from the object and focus it onto a detector. The detector converts the energy into an electrical signal, which is amplified and displayed. IR thermometers capture the invisible infrared energy naturally emitted from all objects. Infrared radiation is part of the electromagnetic spectrum that includes radio waves, microwaves, visible light, ultraviolet, gamma, and X-rays.

2. Do different materials at the same temperature emit different amounts of infrared radiation?

The infrared radiation of an object is transferred in three ways: it is reflected, transmitted, and emitted. Only the emitted energy can be used to measure the actual surface temperature of the object. When IR thermometers are used to measure surface temperature they can potentially sense all three kinds of energy; therefore, all thermometers have to be adjusted to read the emitted energy only. This calibration is accomplished by tuning the IR thermometer to a quantity called a material's emissivity. The emissivity of a perfectly emitting black surface is 1.0. Most substances that are organic or painted have an emissivity of 0.95. This is the value set in the IR thermometer. This means that the IR thermometer will not correctly measure the temperature of shiny metallic surfaces.

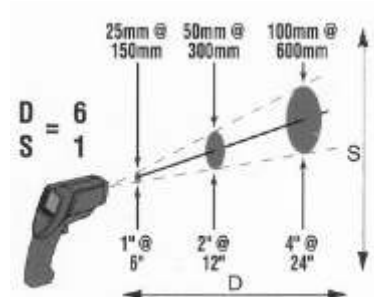


Tip: If you are using a thermometer to measure the surface temperature of a shiny object, compensate by covering the surface to be measured, when it is cool, with masking tape or flat black paint. Allow time for the tape or paint to reach the same temperature as the material underneath! Then, from close range, measure the temperature of the taped or painted surface. For example, the metal fixture of a bright incandescent light (like the one in the kit) could be measured using this method.



3. What area does the IR thermometer measure?

It measures the average temperature of the surface within a circle that is the thermometer's infrared collection area. The "incorrect" situation in the diagram illustrates what happens when you try to measure the temperature of a small surface from too great a distance. The circle becomes larger the greater distance you are away from the surface to be measured. In the diagram, if you were collecting data from the third surface, the infrared collection circle area falls outside the area. The thermometer will collect infrared radiation from the further surface as well, giving you an incorrect reading.



The distance-to-spot ratio (D:S) of an infrared thermometer allows you to estimate how big the infrared collection area will be for any given distance. The distance-to-spot ratio for the thermometer in the kit is 6:1, meaning that the distance from the surface will always be six times the size as the diameter of circle of the collection area.

Within the framework of EcoSchools,
ecological literacy without action is
like music without sound.

How will students take their experiences
from this unit and make a difference in
their homes and schools?

Section 1: Education *in* the Environment

Activity 1.1

Introducing the Unit and the EasySense Data Logger

Activity 1.2

Hot Stuff: Mapping Your Face

Activity 1.3

Mapping the Classroom and School Ground

Activity 1.4

An Excursion to Exhibition Place

1.1

Time: 1-2 hours

Introducing the Unit and the EasySense Data Logger

BLM 1.1a
Understanding
Temperature Differences

Overview

In the first part of this activity, students use data that have been gathered by the EasySense Data Logger, plus their knowledge of heat transfer, to fill-in-the blank exercise. The second part of the activity introduces students to the EasySense instruments through a series of brief activities about temperature. Understanding and identifying temperature differences is fundamental to understanding heat flow.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall - investigate ways in which heat changes substances, and describe how heat is transferred Specific - use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation
Language Arts	- read and demonstrate an understanding of texts - use speaking skills and strategies to communicate for a variety of purposes

Planning Notes

- Make a transparency of BLM 1.1a: Understanding Temperature Differences, or write it on the board.
- Select one or more activities from the Data Harvest *Primary Curriculum Activities for EasySense* guide, included in the EasySense Data Logger Set.

Some related activities from the *EasySense* guide are:

Activity 3: How warm? How cold?

Activity 4: Are your hands warmer than mine?

Activity 5: How warm is our classroom?

Activity 11: The Temperature Game

Activity 13: Hot Drinks

Activity 14: Too hot!

Activity 15: Keeping warm!

Activity 16: Goldilocks

Prior Knowledge

- use of temperature and light sensors
- the lux as a measurement of light hitting or passing through a surface

Teaching / Learning Strategies

1. Have students use the information in the table to fill-in-the blank exercise. Working with a partner or individually, they record their answers in a numbered list in their notebooks. The answers are:
1. 6:15 p.m. 2. 2.1°C 3. outside 4. -1.9°C 5. 0.0°C
6. 7:30 7. 0 8. convection
2. Tell students that the data in the table were gathered with temperature and light sensors from the EasySense Data Logger, and that they will have a chance to use the sensors in a variety of activities about temperature and heat.
3. Choose one or more activities from the *Data Harvest Primary Curriculum Activities* guide that is included in the EasySense Data Logger Set (see the Planning Notes above). The activities introduce students to the sensors and the software.
4. To conclude this introductory activity, have a class discussion about the unit, the Data Logger, and sensors. Ask questions that will help students understand goals for the unit, such as:
 - What do you hope to learn in this unit?
 - What do you think you will be able to do well in this unit?
 - What skills do you think you will be able to improve in this unit?

Understanding Temperature Differences

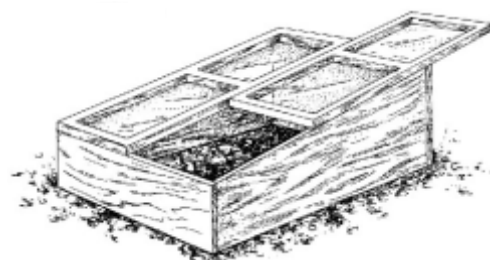
Name: _____

BLM 1.1a

Temperature Inside and Outside of a Cold Frame

Time (p.m.)	Temperature: Thermometer 1 (°C) Inside	Temperature: Thermometer 2 (°C) Outside	Light (lux)
6:15	2.1	0.0	983
6:30	1.9	-0.1	744
6:45	1.4	-0.6	439
7:00	1.3	-0.9	225
7:15	0.6	-1.2	67
7:30	0.3	-1.6	0
7:45	0.1	-1.7	0
8:00	0.0	-1.9	0
8:15	0.1	-1.9	0

Cold Frame



Use data from this chart, plus your own knowledge, to fill in the blanks in the text below.

To protect plants from cold weather, gardeners use something called a cold frame. It is a box with a transparent top, built low to the ground. Sensors were used to gather data about one gardener's cold frame.

The thermometers' first measurements occurred at _____ p.m. At that time, Thermometer 1 recorded air inside the cold frame at _____°C. Thermometer 2 recorded the air temperature _____ the cold frame, and had a reading of 0.0°C.

The lowest temperature outside the cold frame reached _____°C. The lowest temperature inside the cold frame was _____°C.

The transparent top lets sunlight in and prevents heat escape, especially at night. Based on the data, sunset occurred about _____ p.m., when light levels fell to _____. Without the top, the heat would escape because of the flow of heat from a warm region to a cold region. This heat transfer is called _____. Basically, a cold frame is a miniature greenhouse.

1.2

Time: 1-2 hours

Hot Stuff: Mapping Your Face

BLMs

BLM 1.2a
Hot Stuff: Mapping Your Face

BLM 1.2b
Mapping Infrared Energy to reveal structure and shape (enrichment activity)

Overview

This activity provides a fun way of introducing the kit's infrared sensor and its ability to detect “hot spots.” Most students will not have experienced how infrared works, although they may have seen the result of infrared imaging. In this experiment students use an infrared sensor to measure the heat coming off their face. They create a colour code to match the various heat measurements and then use their code to colour in a drawing of a face to make an infrared image.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall - investigate ways in which heat changes substances, and describe how heat is transferred - demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within the earth's systems Specific - use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation - use appropriate science and technology vocabulary - use a variety of forms to communicate
Language Arts	- read and demonstrate an understanding of texts - use speaking skills and strategies to communicate for a variety of purposes

Materials

- ◆ EasySense Data Logger
- ◆ infrared sensor (without the filter)
- ◆ student-drawn picture of a face (simple line drawing)
- ◆ set of pencil crayons (black, blue, red, orange, yellow, white)

Planning Notes

- This experiment uses a very simple setup—just start the EasySense Data Logger and click on Meters on the Homepage.
- Review the material about the EasySense Data Logger and the infrared sensor in the EasySense Manual and on pages 11–15 at the beginning of this resource.
- Don't worry too much about the range of the infrared sensor, as long as it is on the lowest range (20W or 30W). The experiment is comparative and focuses on using normally invisible parts of the spectrum to produce visible images. The point of the experiment is to see the use of infrared to reveal hot spots, structures, and residual heat traces—not the absolute measurement of energy. You might want to modify the purpose, however, if you want to change the focus of the lesson.
- The sensor should be used without the glass filter.
- The sensor detects over an area that is the same diameter as the distance from the object; for example, 10 cm away from the object has a sensing area of 10 cm in diameter.
- It will help if the subject is not having the face warmed by sunlight or the heat from a nearby heat source.
- The colour scale used should be even divisions of the range, with a colour to match each division. For example, on a 50 W/m² range, using 6 colours gives each 8 W/m² its own colour (make the first division and the last division slightly bigger to use up the remainder from the division). Black = 0–9 W/m²; Blue = 10–17 W/m² and so on. You might want to prepare the scale and print it on the face.
- Instead of using a drawn face, it might be more fun to take the students' portraits with a digital camera and have them use Paintshop (or any photo editing package) to edit the colours on their own image.
- Some digital cameras have an infrared setting and can take infrared images, allowing students to make comparisons. Some cameras also have filters that you could experiment with.

Extension Ideas

- ◆ Have students measure the heat loss from the top of their head. How does this change if a hat is worn?
- ◆ Have students place their hand in cold water for a few minutes, and use the sensor to see how long it takes to warm up.
- ◆ Have students measure various objects in the classroom.
- ◆ Use a digital camera that has infrared to take a picture of a face; have students compare a real image with the ones they created.
- ◆ Students may have their own extension ideas.
- ◆ For an activity on mapping infrared energy, see BLM 1.2b: Mapping Infrared Energy to Reveal Structure and Shape. You could do this as a class experiment, or as an extra challenge for a group of students.

Prior Knowledge

- procedures for using the infrared sensor
- electromagnetic frequency spectrum
- radiance and irradiance range (see page 2 of the Infrared Sensor manual)

Teaching / Learning Strategies

1. Tell students that they are going to be conducting an experiment using an infrared sensor. Invite students to share what they already know about infrared. Tell students:
 - Infrared radiation is a type of light, or energy, and is part of the electromagnetic spectrum that also includes radio waves, microwaves, visible light, ultraviolet, X-rays, and gamma. It has a longer wavelength and less energy than light that is visible to the human eye.
 - An object's molecules and electrons are always in motion, vibrating and radiating electromagnetic waves. When the object heats up and its temperature increases, the motion will increase and so will the average wave frequency and the intensity of the radiation. A candle flame gives off so much heat that it has a light that we can see. Objects and humans also give off heat; it's just that it is infrared light, which is not visible to the human eye. An infrared sensor must be used to detect it.
 - You may have seen images of people taken with special infrared cameras. In the image, areas of the body appear in different colours; each colour represents the amount of heat coming out of the body. White is usually used to show the hottest parts and blue/black to show the coldest parts. The infrared camera detects this infrared light. The infrared sensor you are about to use measures power per unit area (watts/m²).
2. Hand out BLM 1.2a: Hot Stuff: Mapping Your Face to the class and review it with them. Introduce the infrared sensor and explain the basics of how to use it. (See the SmartQ Infrared Sensor manual and page 15 of this resource for more information.) Have them create the simple line drawing of a face (or you could draw one and photocopy it).

British astronomer Sir William Herschel discovered infrared radiation around 1800. He detected “invisible” light found just below the red portion of the electromagnetic frequency spectrum. The term “infrared” means “below red”—describing where it is found on the spectrum.

3. Organize students into small groups and have students take turns to conduct the experiment. Work with them to operate the infrared sensor. Then provide time for them to create their images. While groups wait for their turn with the sensor, encourage them to reread the experiment and the information about the sensor (in the SmartQ manual).
4. Conclude the activity by having a class discussion of infrared energy. You could ask the following to guide the discussion:
 - How is infrared imaging used? (weather forecasting; monitoring climate change; astronomy—to detect warm dust around stars not hot enough to give off visible light; medicine—e.g., detection of tumours; manufacturing—e.g., finding weak spots or leaks; in the military—e.g., night vision goggles; TV remotes; finding hot spots in forest fires)

Hot Stuff: Mapping Your Face

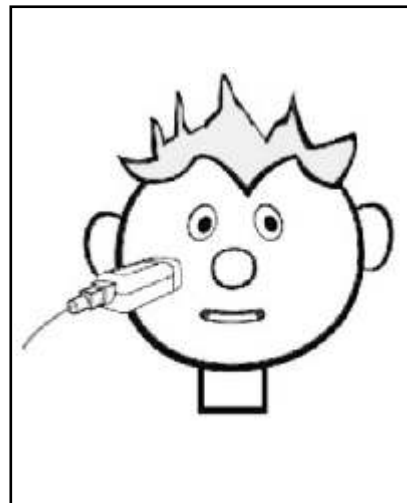
Name: _____

BLM 1.2a

Read the following introduction. Then follow the instructions below.

You may have seen images of people taken with special infrared cameras. In the images, areas of the body are in different colours. Each colour represents the heat coming out of the body. White is usually used to show the hottest parts and blue/black is used to show the coldest parts.

In this experiment, you will use an infrared sensor to measure the heat coming off your face. You will then create a colour code to show the various measurements and colour in a drawing of a face. You will have made an infrared image of your face.



Materials

- EasySense Data Logger
- Smart Q infrared sensor without the filter
- drawn outline of a face
- set of pencil crayons (black, blue, red, orange, yellow, white)

Instructions

1. Find an area to work in that is not getting a lot of heat from the sun or other heat source.
2. Connect the Infrared sensor to Input 1 of the logger.
3. Start EasySense and select Meters from the Homepage. Meters will open with a numeric display of the infrared sensor. Check that the range is set to 20w/r.
4. Point the sensor at an object to see how quickly the sensor responds. This will give you an idea of how long you need to point it at an area of the face to get a good reading.
5. Use your face outline (the drawing) to work out which areas of the face you will measure and in which order. It may help to make a 2-column key or chart for recording the numbers from the sensor against the area of the face being tested.
6. Point the sensor to the first area of the face to measure. Wait until the readings are settled and note them down.
7. Work out a colour code to produce the infrared image (if you use the colours suggested in the Materials list (page 24), then every 3 watts of infrared will need a new colour). Colour the face in using your colour code.

Hot Stuff: Mapping Your Face

Name: _____

BLM 1.2a

Questions

1. Which area of your face gives out the most heat?

2. Which area of your face gives out the least heat?

3. Compare your image with some classmates'. Is the pattern the same for everyone?

Mapping Infrared Energy to Reveal Structure and Shape

Name: _____

BLM 1.2b

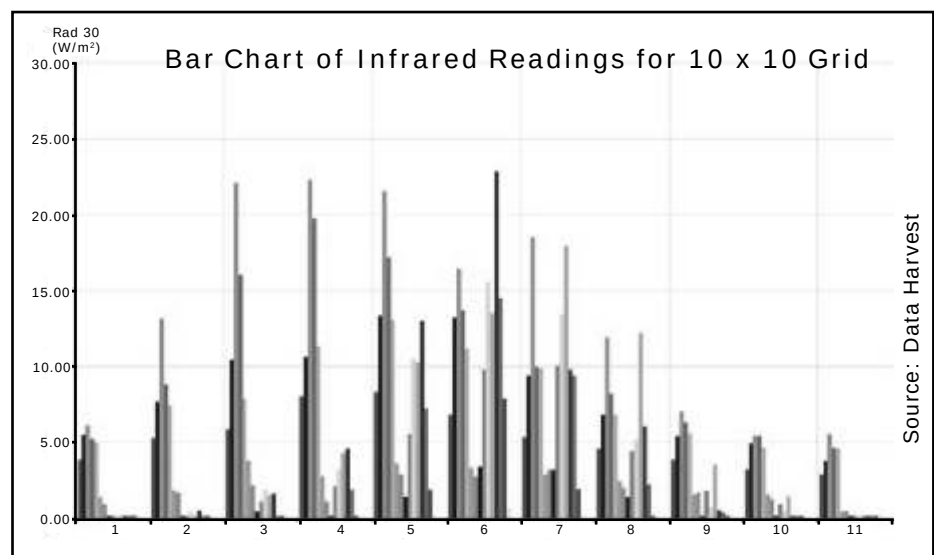
You can lay a grid over the hot object(s) and create a 3D temperature map after transferring the collected data to Excel. This is a basic method that can be modified to measure a number of objects.

Materials (additional to those used in Mapping Your Face)

- laboratory tray (deep)
- 2 plastic bottles filled with hot water
- packing chips
- a grid of 10 cm x 10 cm squares to cover the surface of the tray

Instructions

1. Place at least 2 hot objects in a laboratory tray (small plastic bottles filled with hot water are ideal). Make sure the bottle occupies at least 4 of the grid squares you are going to use)
2. Cover the bottles with packing chips. Level them off and make sure the bottles can't be seen.
3. Place the grid over the surface of the packing chips. Label or identify one corner square as A1.
4. Set the Logger software to record in Snapshot. Have Overlay selected. Click on Start and place the Sensor over square A1. Move the mouse pointer over the graph area and click to make a recording. Move the sensor to the next grid square (A2 or B1) and snap the next reading. Repeat, working your way along the column.
5. When the end of the column is reached, click on Stop (you will only have to do this on the first column; it defines the number of samples in the data set).
6. Move the sensor to the first grid square of the next column and repeat. Work your way across the box recording an infrared value for every grid square.
7. You should have collected data that will look something like this →



Mapping Infrared Energy to Reveal Structure and Shape (cont'd)

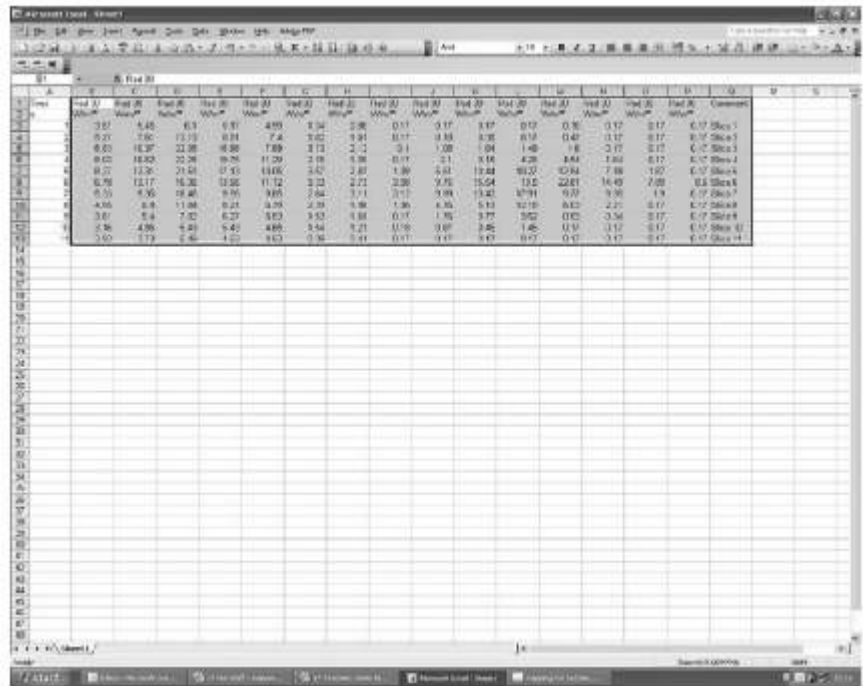
BLM 1.2b

At this point the data will look confusing, but as long as the data have been recorded in data sets that correspond to a grid column, all will be revealed as the analysis continues.

Use the File, Transfer to Excel command to open Excel and place the data into Excel.

For a quick reveal of the data, in Excel, highlight all the data (except the reading number column).

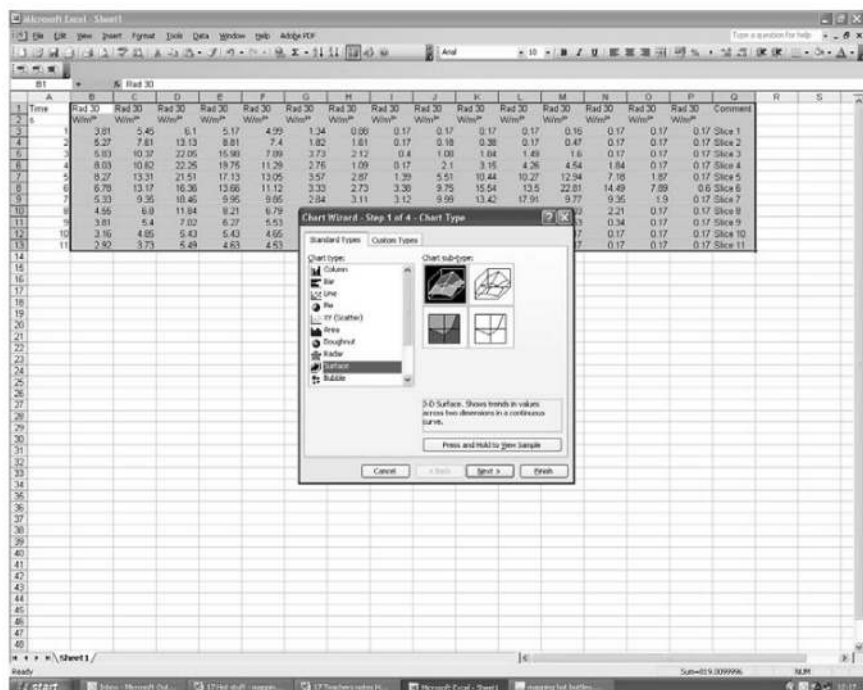
Data Transferred to Excel



Source: Data Harvest

Data Selected for 3D Surface Chart

Click on the Chart icon and select the 3D Surface chart (the exact name and location in sub-menus will vary with editions of the software).



Source: Data Harvest

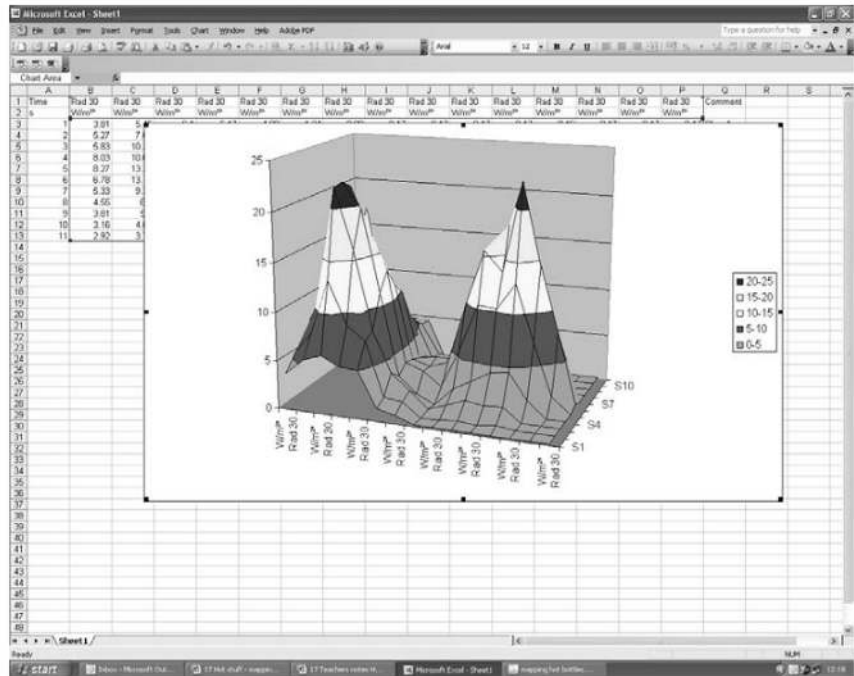
Mapping Infrared Energy to Reveal Structure and Shape (cont'd)

BLM 1.2b

Click on OK and finish.

You should have a chart that will look something like this, at right.

This represents the heat profile of two bottles at right angles to each other hidden from the viewer by a layer of packing chips. The grid was quite coarse at 3 x 3 cm (1 inch x 1 inch). The orientation of the bottles is clearly revealed and some detail of size can be determined. If the grid were made finer, you would increase the resolution and get much more data. You could also create heat maps of windows or doors as part of a study of insulation.



1.3

Time: 2-3 hours

Mapping the Classroom and School Ground

BLMs

BLM 1.3a
Mapping the School
Ground

BLM 1.3b
Microclimates

Overview

The basics of heat transfer are investigated, with the classroom as a starting point. The discussion is then extended to the school ground so that students can quantify how different the temperatures are within the school and in its immediate environment. Understanding and identifying temperature differences is fundamental to understanding heat flow.

Curriculum Connections

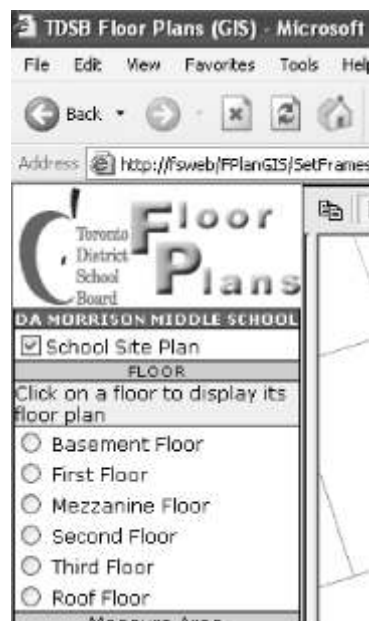
Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall - investigate ways in which heat changes substances, and describe how heat is transferred Specific - use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation
Geography	use a variety of geographic resources and tools to gather, process, and communicate geographic information
Language Arts	- read and demonstrate an understanding of texts - use speaking skills and strategies to communicate for a variety of purposes
Mathematics: Data Management and Probability	collect and organize categorical, discrete, or continuous primary data and secondary data and display the data using charts and graphs, including relative frequency tables and circle graphs

Planning Notes



Tip: Your head caretaker may also have a print copy of your school's site plan. The caretaker may also be able to give you suggestions about areas around the school that will yield good data.

- Find a site map of your school ground.
- To locate your school's site map, you must use a TDSB-networked computer. School site plans of all schools can be found in the Principal's section of the Facility Services home page, a part of TDSBweb not often frequented by teachers. For your convenience, a link to your school's site plan can also be found as follows:
 - Go to the School Services EcoSchools program page at: <http://tdsbweb/program/ecoschools>
 - Click on the School Site Plan icon, shown here, at left.
 - Select your school to get access to your school's site plan and floor plans. Click the first box to see your site plan, and use the magnifying tool to make adjustments to the image size to suit your purposes.
 - Electronically or physically cut and paste the map of your school ground onto the third page of BLM 1.3a: Mapping the School Ground.
 - On this map, label 10 points, A to J, that you think will give you a good range of temperature readings—consider different conditions that will yield different results, such as wind, sun, shade, and ground coverings, such as asphalt.
 - Make copies of BLM 1.3a: Mapping the School Ground (include your own school map) along with BLM 1.3b: Microclimates.
 - Plan student groupings and identify a specific area on the school ground for each group (for step 5).



Prior Knowledge

- use of the infrared thermometer
- mapping and map-reading skills
- skill in enlarging and reducing two-dimensional shapes
- understanding the watt as a measurement of energy

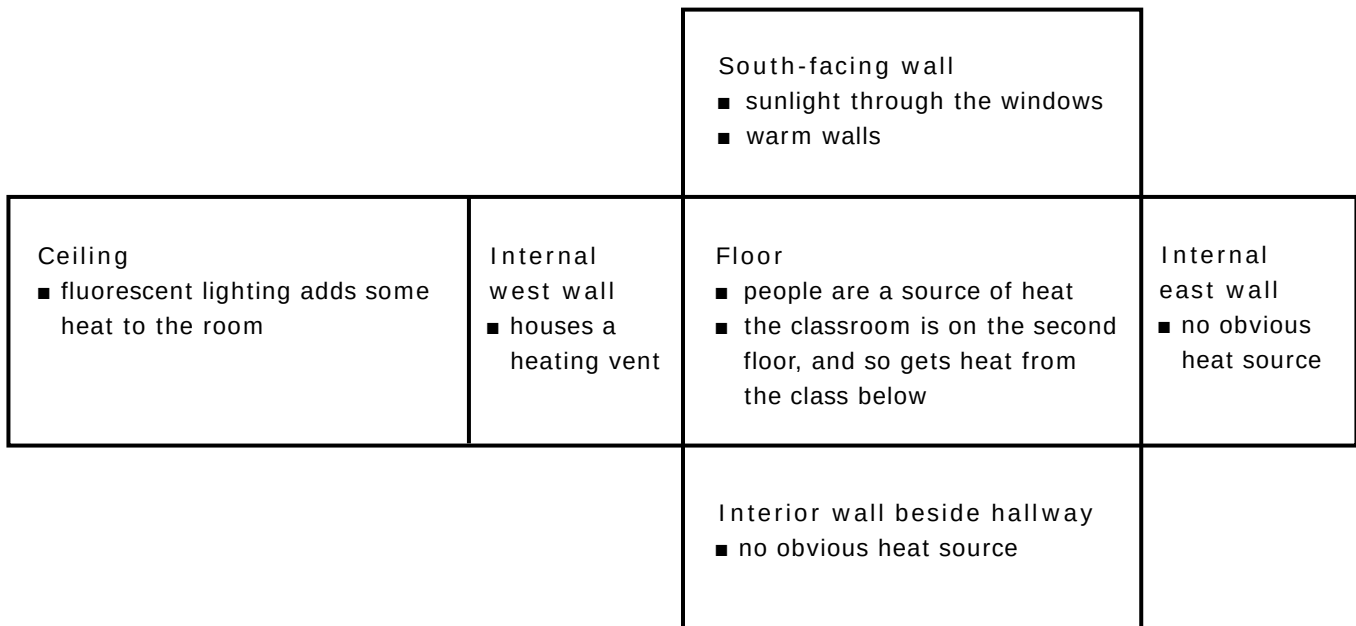
Teaching / Learning Strategies

1. Begin the activity by having students make predictions about temperatures at various locations in the classroom. Have students record the temperatures in a chart, indicating the locations, as in the sample that follows. Then use the nifty non-contact infrared thermometer to determine the temperature of various surfaces in the classroom. The thermometer is ideal for hard-to-reach areas such as the ceiling. Have students record the measurements in a third column of the chart and compare their predictions with the actual temperatures. When you have studied the results together, invite students to offer reasons for the variations in the temperatures.

Sample Temperatures for Typical Classroom

Location	Predicted Temperature (in °C)	Measured Temperature (in °C)
Floor exposed to direct sunlight	25	27
Floor in the shade	21	20
South wall at 1 m	20	20
South wall at 2 m	22	22
Ceiling near the window	27	28
Ceiling near the heating vent	25	26
Outside wall at 2 m	18	20
Interior wall at 2 m	22	21

2. Tell students that they are going to think about heat in their classroom, and ask them how their classroom obtains its heat in the winter. Map the sources of heat on a net diagram of the classroom. Following is a sample net diagram that assumes that the room is the shape of a box. This room is on the second floor. The major sources of heat are labelled.



3. Spend some time discussing the differences and similarities among the heat sources. For each source, question students until you have drilled down to fundamental scientific concepts. This is a great way to diagnose students' prior knowledge about heat concepts. This activity will also provide students with a concrete context for learning the three processes of heat transfer: radiation, conduction, and convection. Review the processes in the class discussion of the questions you present. Sample questions are:
- How is sunlight a heat source?
 - How does the sunlight get into the classroom?
 - Which source of heat is most similar to sunlight as a source of heat?
 - Where does the energy for the fluorescent tubes come from?
 - Why are people a source of heat? (The power rating of a typical adult is about 60W, similar to a 60W incandescent light bulb, which produces 95% heat, and 5% light.)
 - Where does the heat from the vent come from?
 - Can heat come into the classroom through the walls?

4. Use the same net diagram, or create a new one, to explore how the classroom loses heat. Answers should include: through the ceiling (heat rises); through the windows (low thermal resistance, or R-Value); through the walls; and through the door. Connect these forms of heat loss to the three processes of heat transfer: radiation, conduction, and convection.
5. Once you see that students have a grip on some of the concepts, however tenuous, extend the activity and concepts to the outdoors. Have the students work in small groups. Identify partner groups for later comparison of results.
6. Hand out BLM 1.3a: Mapping the School Ground. For this part of the activity, groups complete page 1 of the BLM by recording the current temperature and location of the sun and then studying the map and making predictions about the temperatures at the 10 locations (A to J) that you marked on the map. Assign groups to various locations on the school ground, such as near parked cars, in the shade, in the full sun, on the asphalt. Have them find out the temperatures at these various positions and heights. Ask them to devise some way of recording the temperatures in an organized way so that they will be able to study their data at a future time.
7. Back in the classroom, hand out BLM 1.3b: Microclimates. Have students read the passage and summarize the key points, either on their own or with a partner. Review the main points and then have a discussion to help students make connections between what they learned through their measurement activity and the concept of microclimates. You might ask the following questions. (If the questions are not applicable for your school ground, use another area nearby, such as a park or grounds of a local recreation centre.)
 - If you were planning an outdoor event on the school ground in winter, what would be the best location and time of day? Why? What about an event in June?
 - What spot in our classroom would you say is the prime seat, in terms of microclimates? Why?
 - If we were to plant a vegetable garden on the school ground, what area would have the best microclimate?

Mapping the School Ground

Date: _____

BLM 1.3a

Group Members: _____

1. Record the time of day and the direction in which sunlight is striking the school.

Time: _____

Direction sunlight is striking school: _____

2. Record the temperatures for today as reported in the media.

3. Look at the 10 locations marked on your map of the school ground. Using your knowledge of heat transfer, predict the average temperatures of these 10 locations. Record your predictions in the chart below:

A	F
B	G
C	H
D	I
E	J

4. Explain your predictions.

Mapping the School Ground (cont'd)

BLM 1.3a

5. Go to your assigned area. Identify 3 specific locations near your area that you predict will have very different temperatures. Measure the temperature in these three locations and record the temperatures below. Show the precise locations on the map.

T1= _____

T2= _____

T3= _____

6. Using your knowledge of radiation, conduction, and convection, discuss the differences with your group, and then with your partner group. Jot down any key words that you think you will use to summarize your discussion.

7. Copy all the temperatures from the other groups onto your map.

8. Based on your observations in the area you studied, write a scientific explanation that explains the differences in temperatures at your location.

9. Based on all the observations the class made, what would you conclude is the average temperature outside the school? Explain how you arrived at your conclusion.

Map of Our School Ground

Date: _____

BLM 1.3a

Name of School: _____

Group Members: _____

Map of Your School Ground
(See planning notes #1-3 on page 33)

Microclimates

Date: _____

BLM 1.3b

Read the passage below on microclimates. Use the Word List to help you with unfamiliar words. After your reading, use point-form notes to write a summary of the key ideas in the passage.

A microclimate is the climate of a local or small-scale area that differs from the climate of the larger surrounding area. The term may refer to areas as small as a few square metres (like a garden) or as large as many square kilometres (like a valley). Weather variables such as temperature, rainfall, wind, or humidity are slightly different from that in the larger area. Areas near bodies of water are usually a microclimate, because the water may cool the local atmosphere. In heavily urban areas, brick, concrete, glass, and asphalt absorb the sun's energy. They heat up and then **reradiate** that heat to the surrounding air: the resulting microclimate is called an **urban heat island**.

Another factor contributing to a microclimate is the **slope** of an area, and in particular, the slope's **aspect**. "Aspect" means the direction the slope faces. A south-facing slope in the Northern Hemisphere is exposed to more direct sunlight than its north-facing slope, so it is warmer for longer periods of time.

Think of the difference between a forested park and an industrial park. The natural **flora** in parks absorb light and heat in their leaves. In an industrial park, the buildings' roofs and parking lots just radiate the heat back into the air. Some people argue that overheating of urban environments could be lessened if that absorbed sunlight was put to use as **solar energy**.

Knowing about microclimates can help farmers create the best growing regions for crops. It helps gardeners know where to place plants in their garden—such as in an area they know gets less wind and more sunlight. City planners might choose a certain area in the city for a park or structure because they want it to help cut down that area's high winds.

Do you know where to go in your school yard to get out of the wind? Then you know about microclimates!

Word List

BLM 1.3b

reradiate – to give out energy in the form of radiation after absorbing it
urban heat island – an urban area that is significantly warmer than its surrounding area
slope – a slant; a surface that goes up or down at an angle
aspect – the direction a slope faces
flora – the plants of a region
solar energy – energy from the sun

Microclimates Summary (use point-form notes)

1.4

Time: 1-3 hours

An Excursion to Exhibition Place

BLMs

BLM 1.4a
Exhibition Place
Environmental Plan: an
Overview

BLM 1.4b
Anticipation Guide for
Exhibition Place

BLM 1.4c
Waste Diversion at
Exhibition Place

BLM 1.4d
Green Roof at the Horse
Palace

BLM 1.4e
S-M-A-R-T Movement

BLM 1.4f
Generating Alternative
Energy

BLM 1.4g
The Trigeneration System
in the Direct Energy
Centre

BLM 1.4h
Urban Forestry Initiatives

BLM 1.4i
Hydrogen Fuel Cell
Demonstration Project

Overview

Toronto's Exhibition Place has an ambitious sustainability plan that addresses many different issues related to environmental stewardship. A field trip to Exhibition Place provides students with concrete experience of technologies and initiatives that are at the heart of the Science and Technology Heat in the Environment unit. In this activity, which can be done prior to or following your visit to Exhibition Place, students work in groups to read passages about some of the environmental initiatives. They answer questions about their reading and then share the key points with the other groups.

See the Toronto Renewable Energy Co-operative website for a description of the Grade 7 Solar Systems workshop:
<http://www.trec.on.ca/reeducation/grade7.html>

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred ■ demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within the earth's systems Specific ■ assess the social and environmental benefits of technologies that reduce heat loss or transfer ■ assess the environmental and economic impacts of using conventional and alternative forms of energy
Science and Technology: Interactions in the Environment	■ assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts
Geography	■ describe how humans acquire, manage, and use natural resources, and identify factors that affect the importance of those resources ■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

Planning Notes

- Read over the BLMs for this activity: an overview of Exhibition Place, an Anticipation Guide, and seven readings about Exhibition Place (BLMs 1.4c to 1.4i), to be posted at seven different stations in the classroom.
- Photocopy and post the seven readings at seven stations around the room, and identify the stations with a letter, number, or pictorial symbol (e.g., tree, sun, wind turbine).
- Plan seven student groups of mixed reading abilities and decide which reading (station) you will assign each group.

For more information on Exhibition Place, visit www.explace.on.ca

- Make copies of the worksheet BLM 1.4b: Anticipation Guide for Exhibition Place—you could have one per student or one per group.
- You might collect photos of Exhibition Place and some of the activities associated with it (such as the annual Canadian National Exhibition, the Royal Winter Fair, the Toronto Marlies junior hockey team, the Toronto FC soccer team and stadium), to engage students and aid in recognition of the Exhibition grounds. You might also find photos of the environmental initiatives and place them at the appropriate stations.

Prior Knowledge

Review some terms such as *sustainable development*, *waste diversion*, *emissions*, and *energy efficiency*.

Teaching / Learning Strategies

PART 1: Introductory Class Discussion

1. Show students photos of Exhibition Place and invite them to discuss its various purposes, features, and events. Invite them to share experiences they may have had of visiting there.
2. Ask students to guess how many visitors they think Exhibition Place has per year (tell them they can check their prediction later). Have them think of some challenges that having such a large number of people temporarily in one area can cause. Focus their thinking on issues of waste and environmental concerns, and have them propose some ideas for addressing these issues.
3. Read aloud to students BLM 1.4a: Exhibition Place Environmental Plan: An Overview. Tell students that they will now have a chance to learn more about some of these environmental initiatives.
4. Explain to students that they will be working in groups—first to get their opinions on some issues, then to read about Exhibition Place, then to present the key points of the reading, and finally to re-examine their initial opinions. Introduce the seven stations.

PART 2: Stations

1. Assign students to their group by giving them their letter, number, or symbol, and have them move to the corresponding station. Distribute BLM 1.4b: Anticipation Guide for Exhibition Place (either to each student or one per group) and have students read and discuss the statements, and check “Agree” or “Disagree” for each one. Note that there does not need to be consensus within the groups.
2. Instruct the groups to:
 - read the passage that is posted at their station (point out the Word List that will help them with any challenging vocabulary)
 - answer the set of questions for their reading, in point form
 - identify the key points of their reading and discussion and prepare to present them to the other groups. Each group should choose a speaker.
3. Circulate to help students with their reading and discussions.

PART 3: Whole-class Debrief

1. Have students remain with their groups for a class debriefing session. Have the representatives from each group present the key ideas from their reading. Then ask students to re-examine the Anticipation Guide and ask them to indicate, in the column on the right, any changes they have had in their thinking. Encourage them to think about the information they have learned from the readings as they re-examine the Anticipation Guide. Afterward, ask them to think back to their introductory discussion and the ideas they had for handling large crowds. Ask:
 - Were any of your own ideas reflected in the environmental action plan at Exhibition Place?
 - How do the environmental initiatives at Exhibition Place help the immediate community? Local community? Global community?
2. To conclude, review the 3Rs, and remind students that the first R—Reduce—makes the biggest difference.

Exhibition Place Environmental Plan: An Overview

Date: _____

BLM 1.4a

Exhibition Place is a very valuable piece of land on Toronto's waterfront. The site hosts over 5.2 million visitors a year on its 77 hectares (192 acres). It features the annual Canadian National Exhibition (CNE), which celebrated its 130th year in 2008. It is also home to the Royal Agricultural Winter Fair, Canada Sports Hall of Fame, Toronto Football Club, an equestrian centre, and the Toronto Marlies junior hockey team. The Prince's Gate marks the entry to a number of large buildings, both historic and modern. The buildings are used for conferences, entertainment, and trade shows. With so many buildings, events, and visitors, Exhibition Place faces many environmental challenges. Imagine the amount of garbage produced by 5.2 million people! Imagine the energy needed to keep all those facilities going!

The Board of Governors of Exhibition Place, a local board of the City of Toronto, governs Exhibition Place. In 2004, the Board of Governors adopted a new plan, and environmentalism was a key part of it. Its main goal was to make Exhibition Place more environmentally friendly, both for people who visited it and for the community around it. Since then, Exhibition Place has received a number of environmental awards.

The most important idea behind the Exhibition Place environmental plan is to promote sustainable development and environmental initiatives. The Board of Governors wants to use resources carefully and not have the site create more waste than can be safely disposed of. It wants to deal with its own waste and energy needs without looking to outside sources. In its 130-year history, Exhibition Place has always showcased new ideas. Over the years, the Canadian National Exhibition has brought new technology to Toronto and has educated people about the newest inventions of the times. The environmental plan allows Exhibition Place to continue this tradition by introducing and using the newest green technologies and practices. The Direct Energy Centre, opened in 2006, is an award-winning convention centre that is a model for energy efficiency and environmental technologies.

Goals of the Environmental Plan for Exhibition Place

BLM 1.4a

- To be a leader in using energy-efficient technologies
- To find all opportunities for improving sustainability of the site through better waste management, building improvements, transportation improvements, and greening plans
- Achieve net energy self-sufficiency by 2010
- Achieve 80% waste diversion by 2010

Environmental Actions Taken by Exhibition Place

- Constructing the first urban wind turbine in North America, producing 1.2 million kilowatt-hours of energy annually
- Participating in a hydrogen fuel cell project—installing a hydrogen refuelling station, and using hydrogen fuel-powered John Deere utility vehicles and a hydrogen fuel-powered mini-bus
- Introducing a S-M-A-R-T (Saving Money and the Air by Reducing Trips) commuting program for employees
- Constructing a trigeneration project within the Direct Energy Centre that will generate 30% of that building's energy needs
- Starting a Green Roof Project on the historic Horse Palace building
- Planting trees and other plants to create “green” surfaces
- Using light-emitting diodes (LED) streetlights
- Creating a 100-kilowatt Solar Photovoltaic Power Generation Plant on the roof of the Horse Palace building
- Making older buildings more energy efficient through improvements in lighting, water, heating systems
- Installing a Geothermal Plant in the historic Press Building to replace the old heating/cooling system

The actions that Exhibition Place has taken both to reduce energy use and to produce their own energy will result in approximately 13.7 million kilowatt-hours of energy. The reduction in carbon dioxide emissions resulting from all the actions they have taken will be approximately 10 970 tonnes per year. Exhibition Place's Environmental Plan shows a huge commitment to applying green technologies and for being a leader in sustainable development.

Anticipation Guide for Exhibition Place

Name: _____

BLM 1.4b

Date: _____

- Read the statements. Make a checkmark in the boxes on the left to show whether you agree or disagree with each statement.
- After learning about Exhibition Place at the stations, reread the statements. Make a checkmark in the boxes on the right to show whether you agree or disagree with each statement. In the margin or on the back, jot down some notes explaining how your learning about Exhibition Place affected your decision.

BEFORE the Learning		Statements	AFTER the Learning	
Agree	Disagree		Agree	Disagree
☐	☐	1. The cost of an object should include the cost of not only the materials in the object, but also the safe disposal of the object.	☐	☐
☐	☐	2. Sending waste to a landfill is an acceptable way of disposing of it.	☐	☐
☐	☐	3. When you attend an event, you expect there to be working washrooms and running water that is drinkable.	☐	☐
☐	☐	4. At sporting events, tickets include the cost of electricity to light the field; heat the dressing rooms and washrooms; and prepare and heat the food that is served.	☐	☐
☐	☐	5. The sports team, not the fans, pays for repairs made to a stadium.	☐	☐
☐	☐	6. Plants and green spaces that are created to decrease city smog and global warming can change the temperature of the air significantly.	☐	☐
☐	☐	7. It costs more to tear down a building that loses too much heat than to repair it.	☐	☐
☐	☐	8. Not using your car doesn't really save fossil fuels and reduce carbon dioxide emissions.	☐	☐
☐	☐	9. Paying more for green technology doesn't save money in the long term.	☐	☐
☐	☐	10. Everyone always ends up paying for the waste created by others.	☐	☐

Waste Diversion at Exhibition Place

Name: _____

BLM 1.4c

Date: _____

- Read the following passage as a group. Check the Word List (see reverse side) if you come across unfamiliar words. Work as a group to discuss and answer the questions at the end. Jot down your answers on the page, in point form.
- Together, identify the key points in the passage. Choose a spokesperson from your group to present them to the rest of the class.

Since 2001, Exhibition Place has been part of the City of Toronto Waste Diversion Task Force 2010. This group set aggressive waste diversion targets of 40% by 2006 and 60% by 2007.

In 2005 Exhibition Place generated 2299 metric tonnes of waste and diverted 1156 metric tonnes. This is a 50% waste diversion rate—well ahead of the City's target. In 2006 the Recycling Council of Ontario recognized both Exhibition Place and the Direct Energy Centre in 2006 for their recycling successes. Exhibition Place was awarded a Gold Facility Management Award. The Direct Energy Centre received a Silver Award for Sustainable Technology and a Bronze Award for Facility Management. These awards recognize the achievements of facilities that have adopted an internal waste minimization program, improved resource management, and minimized environmental impacts.

To meet their waste diversion targets, Exhibition Place is now recycling organic waste, batteries, cardboard, lamps, fine paper, rubber tires, wood, hand towels, manure, clean fill, steel, hazardous waste, ink cartridges, cooking grease, engine oil, anti-freeze, car batteries, concrete and asphalt, street sweepings, dry wall, plastic, electric wire, and plumbing copper wire. Future initiatives include introducing compostable drinking cups, installing more efficient washroom fixtures, and reducing paper product waste by using electronic documentation.

Word List

aggressive – active or forceful

diversion – the act of turning aside or
avoid something from reaching

facility – a building designed for certain
activities

generated – made or produced

internal – on the inside; within

minimized – lessened

sustainable – able to keep going

without being weakened or damaged

task force – a group of people working
for a particular objective or project

Name: _____

BLM 1.4c



1. What is “waste diversion”?

2. Why do you think the City of Toronto would need to establish a Task Force to look at waste diversion?

3. What other ways could Exhibition Place address the issue of waste? (Hint: think about the 3Rs.)

4. Name three long-term effects of recycling and of reducing waste.

Green Roof at the Horse Palace

Name: _____

BLM 1.4d

Date: _____

- Read the following passage as a group. Check the Word List (see reverse side) if you come across unfamiliar words. Work as a group to discuss and answer the questions at the end. Jot down your answers on the page, in point form.
- Together, identify the key points in the passage. Choose a spokesperson from your group to present them to the rest of the class.

In Summer 2004, Exhibition Place constructed a green roof on the historic Horse Palace building at a cost of \$44 000. This 232-square metre (2,500-square foot) “meadow” roof is a demonstration project, or a testing project, for Exhibition Place. They plan to use what they learn from this project and build more green roofs on other buildings when their roofs need to be replaced.



In a highly urbanized place such as the City of Toronto, most of the natural landscape has been replaced by hard, non-permeable surfaces. This creates an urban heat island effect. The hard, reflective surfaces absorb the solar radiation and reradiate it as heat. At Exhibition Place, 56 hectares (139 acres) of the total 77 hectares (192 acres) falls into this “hard non-permeable category,” and 20 hectares (49 acres) is roofing.



Recent studies have shown that greening just 6% of the City of Toronto’s rooftops could reduce summer temperatures by 1 to 2 degrees Celsius. This would result in a 5% decrease in electricity demand for cooling, saving an estimated \$1.0 million in energy costs per year. It could also possibly reduce the number of smog days by 5 to 10%.

Green Roof at the Horse Palace (cont'd)

BLM 1.4d

Benefits of Green Roofs

1. Improve air quality – A green roof filters particles from the air moving across it. Through photosynthesis, the plants and grasses convert carbon dioxide (CO₂) into oxygen. It takes just 1 square metre (10.76 square feet) of uncut grass to produce enough oxygen per year to supply one human with his or her yearly oxygen intake requirement. This amount of foliage can also remove approximately 0.2 kilograms of tiny particles from the air every year.

2. Regulate temperature – This reduces the “urban heat island effect.” Through the evaporation cycle, plants on green roofs use heat energy and cool cities at the same time. One square metre (10.76 square feet) of foliage can evaporate over 0.5 litres of water on a hot day. In one year, the same area can evaporate up to 700 litres. *Evaporative cooling* is what happens when a liquid evaporates, typically into surrounding air, and cools an object or a liquid in contact with it. *Latent heat* describes the amount of heat that is needed to evaporate the liquid; this heat comes from the liquid itself and the surrounding gas and surfaces.

A simple example of natural evaporative cooling is perspiration, or sweat, which the body secretes in order to cool itself. The amount of heat transfer depends on the evaporation rate, which in turn depends on the humidity of the air and its temperature, which is why one sweats more on hot, humid days.

3. Insulate buildings – Green roofs insulate buildings by preventing heat from moving through the roof. They also provide shade to a building envelope (a building's outer shell), which is found to be more effective than internal insulation for cooling a building. On a summer day, the temperature of a gravel roof can increase from 25°C to as much as 60° to 80°C. Covered with grass, the temperature of the roof would not rise above 25°C.

4. Retain storm water – Water is stored on a green roof in the soil and taken up by the plants rather than running off the building into the storm sewer system. In summer, depending on the type of plants, green roofs retain 70 to 80% of the precipitation that falls on them. In the winter they retain between 25 to 40%. Green roofs also act as a natural filter for any stormwater that runs off them.

For further information on green roofs visit: www.greenroofs.org

Green Roof at the Horse Palace (cont'd)

BLM 1.4d

Word List

foliage – the leaves of a plant

insulate – keep heat, sound, cold in or out

internal – on the inside; within

non-permeable – not able to let liquids or gases pass through

photosynthesis – the process by which plants use the energy from sunlight to convert carbon dioxide and water into nutrients, with oxygen as the byproduct

reradiate – to give out energy in the form of radiation after absorbing it

urban heat island – an urban area that is significantly warmer than its surrounding area

urbanized – made into cities or towns

1. Why do you think they didn't go ahead and install green roofs on every building at Exhibition Place instead of just the one on the Horse Palace?

2. What causes the “urban heat island effect”? Why is it a problem for cities?

3. How much of the land at Exhibition Place is roofing? Describe this as a percentage of the total land.

4. If we can lower the temperature of the city's air just by installing green roofs, why not do it everywhere, immediately?

5. Summarize the benefits of a green roof in four sentences.

S-M-A-R-T Movement

Name: _____

BLM 1.4e

Date: _____

- Read the following passage as a group. Check the Word List if you come across unfamiliar words. Work as a group to discuss and answer the questions at the end. Jot down your answers on the page, in point form.
- Together, identify the key points in the passage. Choose a spokesperson from your group to present them to the rest of the class.

In Fall 2002, Exhibition Place partnered with Pollution Probe to introduce the S-M-A-R-T (Saving Money and Air by Reducing Trips) movement to its employees to minimize single occupancy vehicle (SOV) trips. S-M-A-R-T provides employees with ways, and reasons, to change their commuting habits to reduce air pollution. S-M-A-R-T promotes car pooling, using public transport, biking or walking, and changing work schedules to allow working at home. Employees are encouraged to S-M-A-R-T commute to improve their health and the environment. If an employee is at work without a car and needs to get home because of a family emergency or illness, or has to work late unexpectedly, the program offers a “Guaranteed Ride Home” that provides taxi fare.



The S-M-A-R-T program at Exhibition Place is headed by a volunteer coordinator and has expanded into a larger environmental group of employees responsible for many different initiatives. Under the program, Exhibition Place takes part in the City of Toronto’s annual Bike Week. Employees ride in the City’s “Group Commute” that features hundreds of cyclists riding together to City Hall. S-M-A-R-T also hosts an annual Bike Week BBQ celebration at Bandshell Park called “Let’s Bike to the Ex!”



In co-operation with the City of Toronto, 35 new post-and-ring bicycle stands were installed on the grounds to add to the existing network of 130 locations for bicycle parking for employees and visitors. For people who carpool, there will eventually be priority parking spaces.

In 2006, working with “Moving the Economy,” S-M-A-R-T installed Mobility hub—a transportation hub on the grounds and at the Exhibition Place GO station. The hubs allow visitors to easily transfer between GO trains, the TTC, and the BikeShare bicycles or CarShare vehicles. In addition, S-M-A-R-T also operates a bike fleet that employees may use to travel between locations on the Exhibition Place grounds.

BLM 1.4e



Word List

commuting – travelling from your home to your work or school

hub – centre of activity

fleet – a group of vehicles operating under one owner

initiatives – strategies to resolve a problem or improve a situation

minimize – lessen

priority – something that has more importance

single occupancy vehicle – a vehicle that has just a driver and no passengers

1. What are some incentives or rewards that employees could be given to help them change their commuting habits and reduce air pollution? Give one example of an incentive and why you think it might work.

2. What other benefits might the employees experience by riding bikes, taking public transportation, or walking instead of using their cars to commute?

3. If you were an employee, how would you feel if your employer put the S-M-A-R-T program into place? How would it affect you? What would be your reasons for supporting it or not supporting it?

For further general information about the S-M-A-R-T program visit:
<http://www.pollutionprobe.org/whatwedo/Smart.htm>

Generating Alternative Energy

Name: _____

BLM 1.4f

Date: _____

- Read the following passage as a group. Check the Word List if you come across unfamiliar words. Work as a group to discuss and answer the questions at the end. Jot down your answers on the page, in point form.
- Together, identify the key points in the passage. Choose a spokesperson from your group to present them to the rest of the class.

Photovoltaic Power Generation Plant

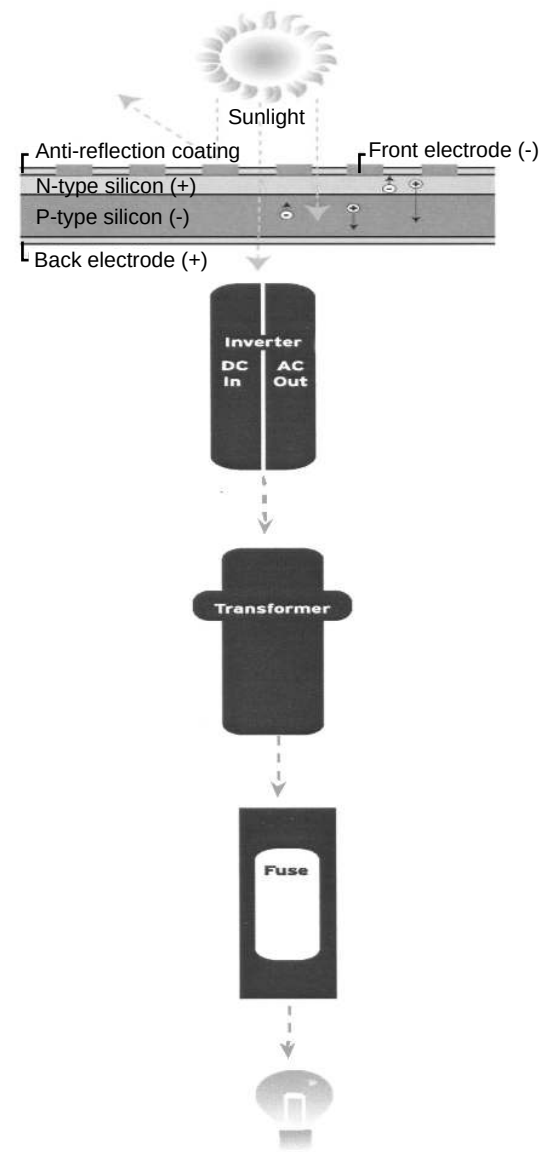
In the summer of 2006, Exhibition Place constructed a 100-kilowatt solar photovoltaic power generation plant on the roof of the historic Horse Palace. The cost was \$1.1 million. Part of the plan was to test and evaluate four different subsystems. Each subsystem is monitored to compare the electrical performances. In addition, the local weather conditions are tracked.

Using the data from this project, a much larger 1.5- to 2-million megawatt generation system is being constructed for the grounds. The system will reduce the annual carbon dioxide (CO₂) emissions of the Horse Palace by approximately 115 tonnes per year. It will generate approximately 120 000 kilowatt-hours of electricity per year, which is enough to power 35 homes.

Exhibition Place will save more than \$10,000 in hydro costs each year. When the project is fully built, it will be the one of the largest in North America.

How do solar photovoltaic plants produce energy?

Solar photovoltaic plants convert sunlight into electricity. The word “photovoltaic” means “light energy.”



Generating Alternative Energy (cont'd)

BLM 1.4f

Photovoltaic (PV) panels are often referred to as *solar panels* because they are made up of several small sections called *solar cells*. Most solar cells are made of silicon, and each cell is designed with a positive and a negative layer to create an electric field, just like in a battery.

Every minute, enough sunlight reaches the Earth to meet the whole world's energy demand. Sunlight is made up of tiny particles called *photons*. A stream of these photons shines on the solar cells, is absorbed in the cells, and cause the electrons in the silicon layers to move. Through this movement an electrical current is created. The current then passes through the electrode at the back of the solar cell and exits through the connecting wire. The connecting wire is attached to an inverter where the power is converted from DC (direct current) to AC (alternating current) power. The AC power is sent to a transformer, where the voltage is increased from 208 to 600 volts to match the building's electrical service. The electrical lines are then attached to the building fuse panel to supply the building with electricity.

Benefits of a solar photovoltaic plant

- Produces pollution-free electricity
- The reduced fuel consumption will displace fossil fuels and make energy bills lower
- “Green energy” generation is noise-free
- Provides a secure source of energy for Exhibition Place
- This pilot project will help create new markets for this technology

Word List

alternative – offering another choice

emissions – gas or other substances released into the air

generate – make or produce

initiative – strategy to resolve a problem or improve a situation

monitored – observed and reviewed over a period of time

phase – a distinct stage in a process

photovoltaic – to do with electric current produced by means of light or other radiant energy

pilot project – an experimental or sample project

silicon – non-metallic, crystalline element that has semi-conducting properties

Generating Alternative Energy (cont'd)

BLM 1.4f

1. Why do you think alternative energy systems such as this cost millions of dollars to install?

2. Who will benefit from the alternative energy at Exhibition Place? Think locally and globally.

3. Explain how the generator works. Draw a picture if it helps. Why is this considered an alternative energy?

For more information on solar photovoltaic plants visit: www.cansia.ca

The Trigeneration System in the Direct Energy Centre

Name: _____

BLM 1.4g

Date: _____

- Read the following passage as a group. Check the Word List (see reverse side) if you come across unfamiliar words. Work as a group to discuss and answer the questions at the end. Jot down your answers on the page, in point form.
- Together, identify the key points in the passage. Choose a spokesperson from your group to present them to the rest of the class.

The Direct Energy Centre at Exhibition Place is one of the largest trade centres in North America, and it features a number of environmental initiatives. One of them is the trigeneration system, which does three things at once: produces electricity, generates heat, and provides cooling. The construction of the trigeneration system will cost approximately \$4.4 million. The Exhibition Place Trigeneration System will be one of the largest in Canada. It is estimated that this system will produce about 12 million kilowatt-hours of electricity per year and that it will eventually become the Centre's only source of power and heat, and most of the cooling. It will displace 7400 tonnes of carbon dioxide (CO₂) emissions, and it will supply approximately 30% of the energy needs of all of Exhibition Place. This project is just the first phase of a district energy system that will be expanded across the whole Exhibition Place site, and that can be a model for other sites.

How does a trigeneration system produce energy?

Trigeneration is a system that burns natural gas to generate three forms of secondary energy—heating, cooling, and electricity. The waste heat produced by the engine is recovered and supplied in the form of hot water to the absorption chiller. This in turn provides cooling, through a chemical process, for the Direct Energy Centre in the summer. In the winter, the waste heat is supplied to augment the heating boilers. The recovered heat improves overall plant efficiency from 40% (typical of a standard engine) to an 80% level.

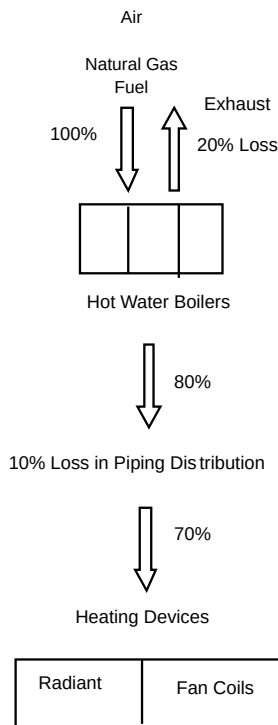
Benefits of the trigeneration system

- Energy security – More than 30% of the energy needs of Exhibition Place will be met by the trigeneration system. Even if there is a power outage, it can provide its own energy.
- Energy cost savings – It is estimated that there will be energy savings of \$30 million over the life of the trigeneration system.
- Emission reductions – It should reduce carbon dioxide (CO₂) emissions by 7400 tonnes per year.

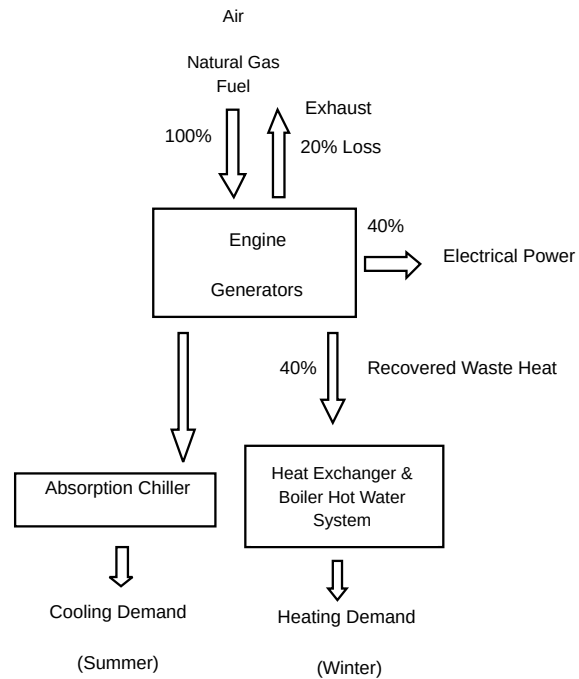
The Trigeneneration System in the Direct Energy Centre (cont'd)

BLM 1.4g

Present Heating System



Trigeneneration System



Word List

absorption chiller – a cooling device that is driven by heat energy

augment – increase or add to

emissions – gas or other substances released into the air

generates – makes or produces

initiative – strategy to resolve a problem or improve a situation

phase – a distinct stage in a process

secondary – next after the first in importance or order

site – place or location

trade centres – buildings where trade shows are held; business offices or complexes

trigeneneration – generation of three (tri) things

The Trigeneration System in the Direct Energy Centre (cont'd)

BLM 1.4g

1. What are the three forms of secondary energy that are generated in the trigeneration system?

2. When you read about the benefits of the trigeneration system, which one is most important to you? Which might be most beneficial to Exhibition Place? Explain your reasons.

3. Study the diagrams of the two types of heating systems. What are the major differences?

Urban Forestry Initiatives

Name: _____

BLM 1.4h

Date: _____

- Read the following passage as a group. Check the Word List if you come across unfamiliar words. Work as a group to discuss and answer the questions at the end. Jot down your answers on the page, in point form.
- Together, identify the key points in the passage. Choose a spokesperson from your group to present them to the rest of the class.

Exhibition Place is playing its part in the urban forestry initiatives being led by the City of Toronto's Tree Advocacy Planting Program (TAPP). TAPP has the job of cultivating and caring for the City's entire urban forest by planting trees, spreading awareness, and lobbying for increased protection for trees. Exhibition Place is doing its share to preserve and renew the City's urban forest. In a special ceremony in 2004, Exhibition Place paid tribute to its oldest elm tree still standing in the City of Toronto; it's over a hundred years old. With 2570 trees on the site and over 20 hectares (51 acres) of parkland, Exhibition Place plans to spend \$50 000 annually on its forestry program.

Recently, Exhibition Place has also been part of two very special projects—the Sakura Tree Project and the development of a naturalized garden. The Sakura project, in partnership with the Committee of the Japanese Consul General's Office in Toronto, resulted in the planting of 68 Japanese Sakura (cherry) trees at Exhibition Place. The naturalized garden surrounds the base of the wind turbine and the hydrogen fuel plant. It is planted with low-maintenance native plants and trees.



Urban Forestry Initiatives (cont'd)

BLM 1.4 h

A further aim of the reforestation commitment at Exhibition Place is to “green” the hard surfaces that cover much of Exhibition Place and are a necessary part of the site’s trade shows and businesses. Through the strategic planting of trees, however, these surfaces can be shaded to reduce or eliminate the urban heat island effect.

Benefits of the urban forest

- Trees improve the air quality—each tree can reduce airborne dust particles by as much as 7000 particles per litre of air
- Trees absorb carbon dioxide
- Trees help prevent soil erosion and provide effective insulation against noise
- One large tree can provide a day’s oxygen for up to 4 people
- Trees help reduce energy costs by shading buildings in the summer and protecting against winter winds



Irrigation

As part of its environmental approach, Exhibition Place uses Lake Ontario water, delivered through 8.8 kilometres of piping across the site.



Word List

advocacy – the act of publicly supporting or defending something

Consul General – a government official in a foreign city

initiatives – strategies to resolve a problem or improve a situation

lobbying – trying to persuade or influence public officials

insulation – material used to keep heat, sound, cold in or out

naturalized garden – a garden that has native plant species

reforestation – replanting of trees

strategic – carefully designed or planned to achieve an outcome

urban – to do with cities or towns

urban heat island – an urban area that is significantly warmer than its surrounding area

Urban Forestry Initiatives (cont'd)

BLM 1.4h

1. What is an urban forest?

2. What do you think the trees need to be protected from?

3. Compare the benefits of planting trees on the ground with installing a green roof on buildings.
How do both help eliminate the urban heat island effect?

4. How can having more trees help save energy? Write your answer or draw a picture to illustrate how planting trees in special places can protect buildings.

For further information about tree advocacy, visit: www.toronto.ca/tapp

Hydrogen Fuel Cell Demonstration Project

Name: _____

BLM 1.4i

Date: _____

- Read the following passage as a group. Check the Word List (see reverse side) if you come across unfamiliar words. Work as a group to discuss and answer the questions at the end. Jot down your answers on the page, in point form.
- Together, identify the key points in the passage. Choose a spokesperson from your group to present them to the rest of the class.

In the summer of 2003, Exhibition Place launched the Fuel Cell Demonstration Project. This project is part of the City of Toronto's Hydrogen Village Initiative. Over the years it has demonstrated the following hydrogen fuel cell projects:

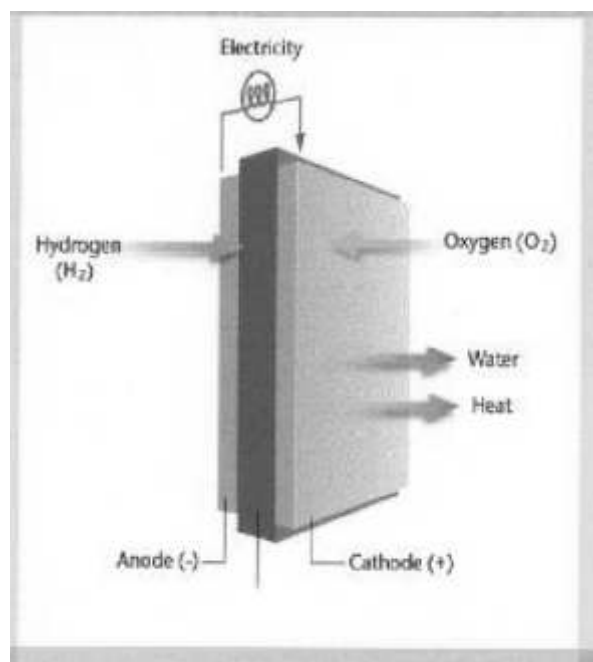
- A 50 kilowatt-hour HySTAT fuel cell generator adding to the existing electricity sources in the Direct Energy Centre
- a fuel cell forklift
- The GEM—a small urban vehicle
- Hydrogen refuelling station
- 4 John Deere fuel cell Work ProGators

What is hydrogen?

Hydrogen is a colourless, odourless gas that is 14 times lighter than air. It does not exist in its pure state in nature but must be extracted from other compounds. Hydrogen is the ultimate climate-friendly fuel, with zero carbon content. It is the carbon content in fuels that contributes greatly to air pollution and climate change.

How do hydrogen fuel cells work?

A hydrogen fuel cell is an electrochemical device that produces energy by combining hydrogen and oxygen without combustion. Hydrogen enters the fuel cell on one side and is split into protons and electrons by a catalyst (platinum).



Hydrogen Fuel Cell Demonstration Project (cont'd)

BLM 1.4i

When split, the electrons are forced to flow one way creating an electrical current that can be captured before the electrons reach the cathode side of the catalyst.

When the protons and electrons join again on the cathode side of the fuel cell, they are mixed with oxygen to produce water and heat. By putting a number of individual fuel cells together in a stack and then building an operating system around the stack, you can make enough power to turn a motor, which can drive a vehicle.

The Exhibition Place hydrogen refueling station was the first such refueling station within the City of Toronto. The Hydrogenics HyLYZER 65 Electrolyzer uses the Exhibition's renewable energy and, with water, produces hydrogen and oxygen. The hydrogen is stored in a specially designed cylinder. The John Deere ProGators can drive up to the hydrogen dispenser and be refueled. It's just like a "gas station" except that it supplies hydrogen—and then the ProGators are ready to go!



Benefits of hydrogen fuel cells

- It's clean – using hydrogen in an energy conversion device produces zero emissions; only electricity and water are produced
- It's abundant – hydrogen is the most abundant element in the universe
- It promotes energy security – hydrogen can be produced in a variety of ways, from water, natural gas, biomass, and ethanol, to name only a few

Word List

abundant – very plentiful

catalyst – a substance that speeds up a reaction without being permanently changed itself

cathode – a fuel cell's positively charged electrode

combustion – burning

extracted – taken out or obtained by a process

generated – made or produced

urban – to do with a town or city

Hydrogen Fuel Cell Demonstration Project (cont'd)

BLM 1.4i

1. What is hydrogen? Why is it a climate-friendly fuel?

2. What are your predictions for the use of hydrogen-fueled vehicles in the future?

3. How do these hydrogen fuel cell demonstration projects that Exhibition Place designed help the greater community?

For more information on hydrogen fuel cells, visit: www.hydrogenics.com

Section 2: Education *about* the Environment

Activity 2.1

The Snake that Became a Thermometer

Activity 2.2

Climate Change: The Big Picture

Activity 2.3

Trapping Energy: Building a Solar Oven

Activity 2.4

The Urban Heat Island Effect: Analyzing Temperature Maps

Activity 2.5

Surfaces: Metal Foils

Activity 2.6

Life Cycle Analysis: Embedded Energy

Activity 2.7

Exploring Canadian Winds

2.1

Time: 1 hour

The Snake that Became a Thermometer

Overview

This is a brief activity that introduces the Education *about* the Environment section and the topic of climate change.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within the earth's systems Specific ■ describe the role of radiation in heating and cooling the earth, and explain how greenhouse gases affect the transmission of radiated heat through the atmosphere
Science and Technology: Interactions in the Environment	■ investigate interactions within the environment, and identify factors that affect the balance between different components of an ecosystem
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

BLMs

BLM 2.1a
The Snake that Became a
Thermometer

Materials

- ◆ preselected websites (see Planning Notes)
- ◆ *Nature* journal, Vol. 457, Feb. 5, 2009, p. 715

Planning Notes

- Preselect some related websites, using the key words titanoboa and poikilotherm.
- Prepare BLM 2.1a: The Snake that Became a Thermometer for display or as a handout.

Prior Knowledge

- difference between cold-blooded and warm-blooded animals
- meaning of *fossils* and *paleontology*

Teaching / Learning Strategies

1. Display BLM 2.1a: The Snake that Became a Thermometer and read it aloud as students follow along.
2. Ask students what more they would like to know about the snake or related topics. Record their questions on a chart.
3. Have students research to find answers to the questions they have raised. You could assign questions to groups of students, or have one group of students conduct all the research and report back. Provide time for sharing the research results.
4. If you don't have time for students to research, have a class discussion about the article (on the BLM), using questions such as the following:
 - Are humans warm-blooded or cold-blooded?
 - Why don't really large snakes live naturally in our part of the world?
 - How is the snake a thermometer?
 - How does knowing about climates in prehistoric times help scientists today?

The Snake that Became a Thermometer

BLM 2.1a

In February 2009, scientists reported an amazing discovery: skeletal remains of the biggest snake the world has ever known. The fossilized remains of the snake were discovered in Colombia, South America. Researchers think that the giant lived between 58 and 60 million years ago.

The experts calculate that the snake was 12.8 metres long and weighed 1135 kilograms. That's about as long as a school bus and as heavy as an average car! Jason Head is a Canadian paleontologist (someone who studies fossils from prehistoric times) who was part of the team that analyzed the fossils. He said that the snake's body would have been so wide that, today, it would have to squeeze to get through a doorway.

Maybe you're wondering why you are reading about a prehistoric snake in a unit on heat in the environment. Here's where it gets really interesting!

Snakes are cold-blooded, meaning they don't produce their own body heat. They depend on heat from the environment for their metabolism—the process that changes food into energy and causes growth. Their size is determined by the temperature of where they live. Most large snakes today, like anacondas and pythons, live in tropical areas, where the temperatures are high. The scientists figure that, for this giant snake to have grown that big, the average temperature would need to be at least 30–34 degrees Celsius. That's how the snake became a thermometer!

This important information helps scientists know more about the climate and environment of the tropics in prehistoric times, and how they compared with climates of other regions of those times. It also helps them study how ecosystems respond to climate change, and what happens when temperatures increase and decrease—information that is highly relevant to us today.

2.2

Time: 2 hours

Climate Change: The Big Picture

Overview

In this activity, students learn about greenhouse gases and their effects on climate change. They examine the effects of climate change on Arctic ice and how it affects a particular species: polar bears. To conclude, students discuss various solutions to cutting down on greenhouse gas emissions.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred Specific ■ assess the environmental and economic impacts of using conventional and alternative forms of energy ■ describe the role of radiation in heating and cooling the earth, and explain how greenhouse gases affect the transmission of radiated heat through the atmosphere ■ identify common sources of greenhouse gases and describe ways of reducing emissions of these gases
Science and Technology: Interactions in the Environment	■ investigate interactions within the environment, and identify factors that affect the balance between different components of an ecosystem
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

BLMs

BLM 2.2a
Greenhouse Gases

BLM 2.2b
Facts about Climate
Change: Matching Game

BLM 2.2c
Arctic Ice

You might wish to show a related DVD or video, or other visuals, to prompt discussion about what students already know about the greenhouse effect and climate change.

Planning Notes

- Read over the BLMs for this activity and plan whether you want students to work in pairs or larger groups. Make copies accordingly.
- You might want to gather various resources such as DVDs, books, photos, and websites on climate change and Arctic ice for students to study.

Prior Knowledge

- review terms such as *emissions*, *ecosystems*, and the difference between *weather* and *climate*.

Teaching / Learning Strategies

1. Use BLM 2.2a: Greenhouse Gases either as a handout for pairs of students to read, or read it aloud from an overhead while students follow along.
2. Hand out BLM 2.2b: Facts about Climate Change: Matching Game and have students complete it on their own or with their partner.
3. Introduce the fact that climate change causes many complex changes to both natural and human systems. Ask students to offer examples (rise in sea levels, increase in global precipitation, thawing of frozen ground, extreme temperatures and drought, effects on ecosystems). On the board or chart paper, use their responses to create a chart like the following and build the chart together as a class. (Part of the third row has been filled in as an example.)

Climate Change Effect	What Might Result	Effects on Animals, Plants, and/or Humans
Rising sea level		
More sunshine (heat energy)		
Increase in precipitation (rainfall or snowfall)	- flooding	- fish in rivers might not reproduce successfully
	- erosion	- problems with drainage; damage to homes and buildings
Decrease in precipitation (rainfall or snowfall)		- less soil for farmlands

You might want to show students a map of the current extent of Arctic sea ice and the amount by which it has diminished. The following website posts current images: <http://nsidc.org/arcticseaicenews/>

4. Tell students that they will now focus on one effect of climate change: the loss of Arctic ice. Distribute BLM 2.2c: Arctic Ice (to whatever groupings you decided on earlier) and have students read the material and do the activity. The answer to the Arctic Melting Feedback Loop is as follows:
 1. Increased greenhouse gas emissions from human activity
 2. Increased global warming
 3. More Arctic ice melts in summer
 4. Less solar energy is reflected back to space
 5. Exposed ocean absorbs more heat
5. To conclude the lesson, have a class discussion about actions humans can take to cut down on greenhouse gases. Include discussion of both local and global initiatives. You could organize the discussion by separate topics:

Transportation: use vehicles less by biking, walking, taking public transport, sharing transport; develop more fuel-efficient vehicles; have trucks transport goods on return trips rather than travelling with no load

Recreation: choose low-impact activities like hiking and canoeing rather than using motorized sports vehicles

Shopping: choose goods that have used less energy in their production and transport (buy local goods; buy less and reuse more; buy items with less packaging)

Greenhouse Gases

BLM 2.2a

What are greenhouse gases?

You probably know that a greenhouse is one of those buildings with a glass or plastic roof and walls and that they are used for growing plants because they absorb the warmth from the sun's rays. So when we say “greenhouse,” we simply mean a place that has a very warm atmosphere.

The Earth has a similar atmosphere that surrounds the globe and keeps it—and us!—warm. The atmosphere is made from a mixture of gases—nitrogen, oxygen, and argon are the big three, plus there are others such as carbon dioxide, methane, ozone, nitrous oxide, and water vapour. They're called greenhouse gases because they create a warm environment for our Earth.

How, you ask? The sun radiates through the atmosphere to warm the surface of the Earth. The Earth absorbs the radiation. But the Earth also cools its surface by sending heat energy in the form of infrared radiation back to space. On its way back, though, the greenhouse gases absorb some of that radiation and then reradiate it—in all directions throughout the atmosphere and also back to the Earth's surface. And that makes the Earth's temperature higher than it would be without those gases. It's sort of like the sun and Earth are playing catch and the greenhouse gases intercept Earth's throws and then make a toss back to Earth.

So what's the problem with greenhouse gases?

Well, you learned that greenhouse gases can make the Earth's temperature higher. So it makes sense that if the greenhouse gases increase in quantity or concentration, they absorb more of the Earth's outgoing radiation. And that increases the Earth's temperature that much more. The more greenhouse gases, the hotter the Earth.

Greenhouse Gases (cont'd)

BLM 2.2a

Why are greenhouse gases increasing?

Human actions can cause increases in the quantity and concentration of the greenhouse gases.

- Methane comes from decay of plant and animal material (like in landfills); from wetlands; from livestock farming; from leakage during the processing of fossil fuels like coal and gas.
- Carbon dioxide (CO₂) comes from the burning of fossil fuels.
- Nitrous oxide comes from soils and nitrogen fertilizers.
- We have also added new synthetic gases, like chlorofluorocarbons (CFCs).

Are humans responsible for climate change?

The Earth's climate is a big system, and it's affected by smaller systems such as the atmosphere, the hydrosphere (oceans and rivers), and the biosphere (plants, forests, soil)—and the way they interconnect. So the climate does have many natural changes and variations. For example, there have been natural changes from warmer periods to cooler periods. Natural events like volcanic eruptions or solar activity can cause changes to the climate. However, scientists have tracked and compared human activity against trends in climate over many years. They have found that the rate of global warming and climate change is much more than can be attributed to natural changes.

Facts about Climate Change

Name: _____

BLM 2.2b

Draw lines to match the questions with the answers.

Date: _____

Where did the
2007 UN Climate
Change Conference
take place?

carbon dioxide,
methane, and
nitrous oxide

By how much has
the Earth warmed
over the last
hundred years?

the burning
of fossil fuels

What type of heat
transmittal occurs
when the sun heats
the Earth?

Bali,
Indonesia

What is a
type of
synthetic gas?

chloro-
fluorocarbons
(CFCs)

What is a
major source
of carbon
dioxide?

radiation

What are some
greenhouse
gases that
humans have
increased?

0.74°C

Arctic Ice

Name: _____

BLM 2.2c

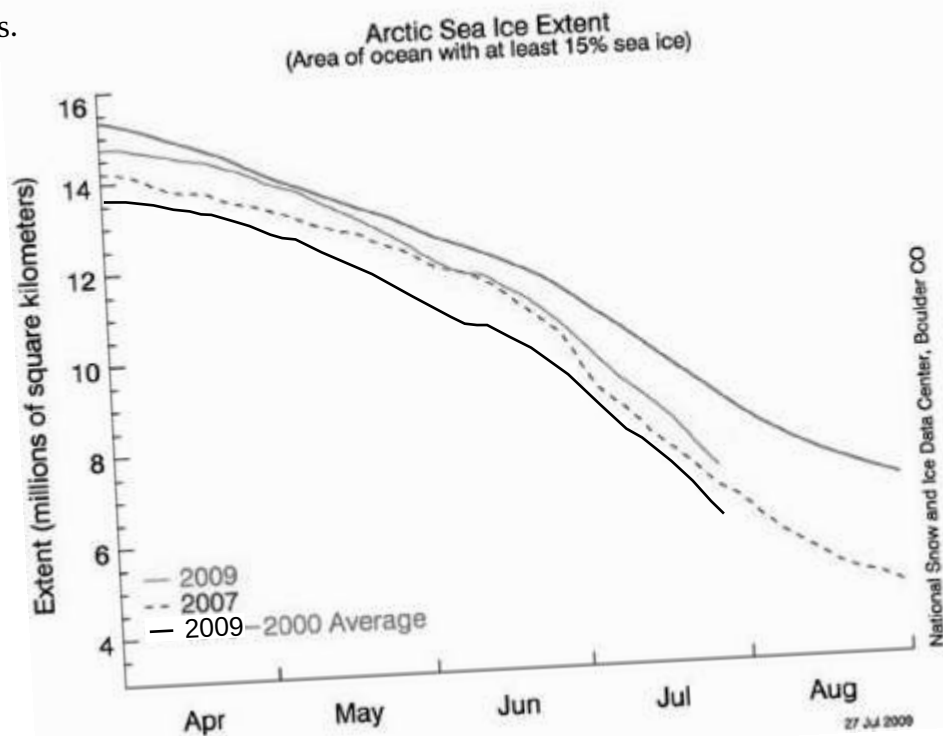
Date: _____

Read the following passage and study the graph. Then complete the activity on the next page.

Climate change has a serious impact on our oceans. The increase in global temperatures melts Arctic ice and glaciers. The melting of Arctic ice will cause a rise in sea levels.

If Arctic ice thins and melts, there is less white ice and snow to reflect the sunlight, or the solar energy, back to space. The larger expanses of dark water of the oceans absorb the heat, leading to further increase in global temperatures.

The following graph shows the changes in the extent of Arctic sea ice between April and August from 1979 to 2009. The extent is measured in millions of square kilometres. Notice the drop in sea ice extent over the summer months. Scientists measure ice extent with satellites.



<http://nsidc.org/arcticseaicenews/>

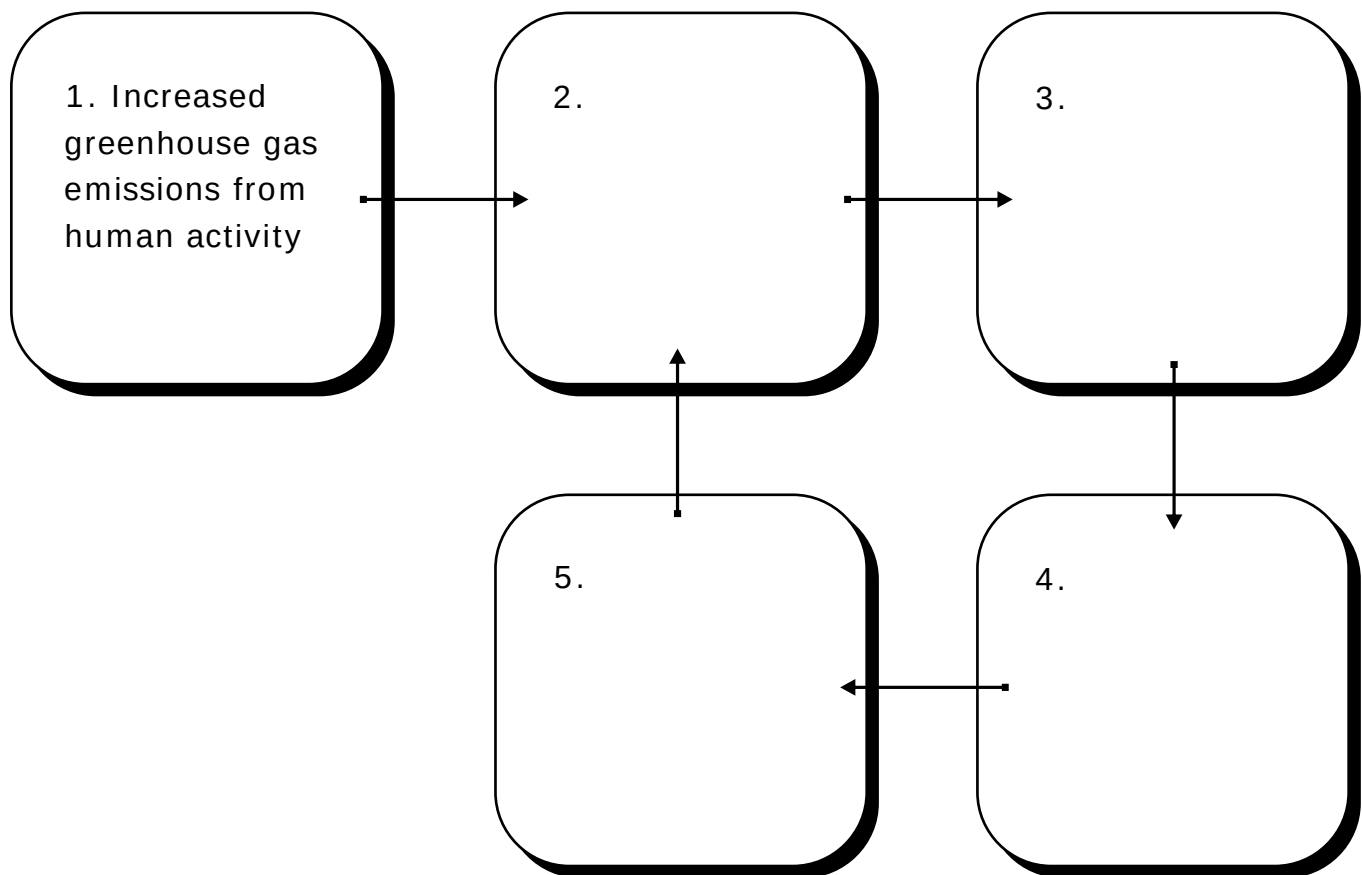
Arctic Ice (cont'd)

BLM 2.2c

Read the following four steps that are part of a cycle of climate change and melting Arctic ice. Place the steps in their correct order in the chart below. (This type of diagram is called a “feedback loop.”) The first step has been provided. Share and compare your answers with another pair of students.

- Exposed ocean absorbs more heat
- Less solar energy is reflected back to space
- Increased global warming
- More Arctic ice melts in summer

Arctic Melting Feedback Loop



2.3

Time: 3 hours

Trapping Energy: Building a Solar Oven

BLMs

BLM 2.3a
How to Make Your Pizza
Box Oven

BLM 2.3b
Pizza Box Oven Summary

Overview

In this activity, students construct a pizza box solar oven and use it to bake a snack. This activity needs to be done on a sunny day, in a place that receives direct sunlight. The purpose is to help students understand the greenhouse effect by experiencing the basic idea of heat being trapped. The activity leads to discussion about greenhouse gases and the consequences of their increase.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred Specific ■ assess the environmental and economic impacts of using conventional and alternative forms of energy ■ describe the role of radiation in heating and cooling the earth, and explain how greenhouse gases affect the transmission of radiated heat through the atmosphere ■ identify common sources of greenhouse gases and describe ways of reducing emissions of these gases
Science and Technology: Interactions in the Environment	■ investigate interactions within the environment, and identify factors that affect the balance between different components of an ecosystem
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

Materials

- clean, used pizza boxes
- black construction paper
- aluminum foil or inside-out potato chip bags
- clear plastic (heavy plastic laminate works best)
- non-toxic glue, tape, scissors, rulers, magic markers
- wooden dowels or straws
- temperature probes
- prepared cookie dough or ingredients for s'mores (graham crackers, chocolate, marshmallows)

Try making cookies, English-muffin pizzas, or s'mores. Be sure you are aware of any allergies students may have and be mindful of dietary restrictions when making food choices. Also be sure that food is fully cooked before eating.

Planning Notes

- Review the background material below and the process for making the pizza box ovens.
- Send home a letter to parents/guardians several weeks in advance so that students can bring the necessary materials to class.
- Find out about any food allergies in the class.
- Gather the materials required. Decide on the student groupings you will use, and photocopy the necessary number of BLMs.

Prior Knowledge

- review the key ideas about greenhouse gases and climate change from Activity 2.2: Climate Change: The Big Picture.

Background

A common analogy to explain global warming is the greenhouse. Anyone who has ever walked into a greenhouse, or entered a car parked in the sun on a hot day has felt the greenhouse effect. Why is it hotter inside the car than outside? It is because the air inside the car cannot circulate with the outside air and get dispersed. So the heat inside the car increases. That's why opening all the windows cools the car. This is exactly how a greenhouse works.

A greenhouse admits the sun's energy, and then reduces or eliminates cooling by cutting off air circulation that would allow for the cooling process. So the greenhouse heats up. This idea of heat being trapped is the basis for the comparison of the greenhouse to the Earth's atmosphere. Although the actual process is quite different, the analogy helps people understand the basic idea of heat being trapped—which is what building the solar oven will allow students to do.

The outputs of many human activities are gases such as carbon dioxide and methane. Once in the atmosphere, these gases—called greenhouse gases—block heat from escaping into space. They are increasing the temperature of our planet. The consequences for ecosystems and societies may be severe.

Teaching / Learning Strategies

Alternative option

Do not provide detailed instructions as outlined in BLM 2.3a. Instead, have students assemble and examine their materials (as outlined in BLM 2.3a). Provide students with questions that will be the basis for the construction project, e.g., “How could you use the materials collected to build an oven that uses the Sun's rays to cook food?”

Direct your students to brainstorm a solar oven design. Have them get permission before proceeding to the construction phase.

When students are testing their ovens, encourage them to use a two-column format to record their observations and questions (see BLM 2.3b).

1. Introduce the activity by asking students why a thermos works and why car interiors get really hot in the summer. Then ask how they think a pizza box could be transformed into a solar cooker, or oven.
2. Organize students into their groups and hand out copies of BLM 2.3a: How to Make Your Pizza Box Oven. Review the instructions with them and then invite them to proceed with constructing their oven. Circulate to assist as required. Or consider the alternative option (sidebar).
3. Invite students to think of improvements they could make to the basic design to increase the inside temperature of the pizza box to make it more effective for baking.
4. Expect cooking times to be at least twice as long as normal cooking times. While the food is cooking, hand out BLM 2.3b: Pizza Box Oven Summary and have students complete it.
5. Eating the food “fresh from the oven” is a great reward!
6. To end the activity, have a class debriefing. Invite students to discuss their oven's temperatures and performance and their ideas for improving the design. Ask some questions such as:
 - What did you learn about heat from making the pizza box oven?
 - What type of heat transmission was demonstrated?
 - Why do you think the black construction paper was used? The aluminum foil?
 - What other types of heat transmission do we use to cook food?

How to Make Your Pizza Box Oven

Name: _____

BLM 2.3a

Materials

- clean, used pizza box
- black construction paper
- aluminum foil or inside-out potato chip bags
- clear plastic (heavy plastic laminate works best)
- non-toxic glue, tape, scissors, ruler, magic marker
- wooden dowel or stiff straw

Diagram 1

- Draw a three-centimetre border all around the sides of the top of the pizza box.
- Cut along only the dotted lines shown to make a large reflecting flap. The solid line at the back of the box is uncut.
- Score the back solid line by drawing over the line with a sharp pencil.

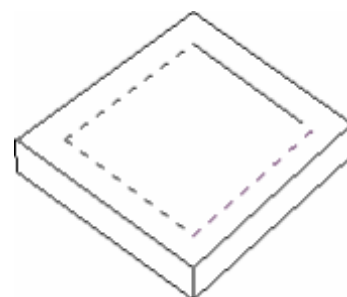


Diagram 2

- Fold the flap backwards along the solid line.
- Cut a piece of aluminum foil to fit on the inside of the flap. Smooth out any wrinkles and glue into place.
- Cover the opening with transparent plastic. Tape it down so that the top of the pizza box can still be opened. The plastic cover should be tightly sealed so air cannot escape through the window when the top of the pizza box is closed.

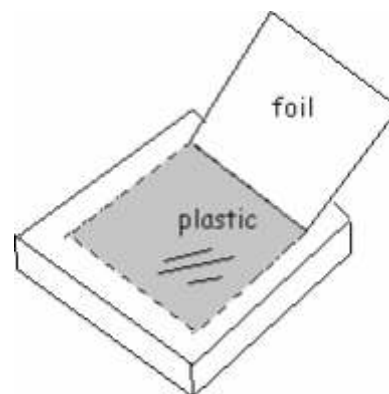


Diagram 3

BLM 2.3a

- Cut another piece of aluminum foil to line the bottom of the pizza box and carefully glue into place.
- Cover the aluminum foil with a piece of black construction paper and tape into place.

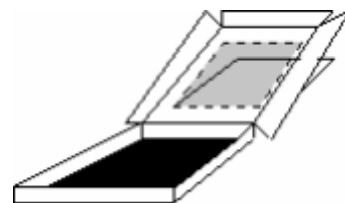
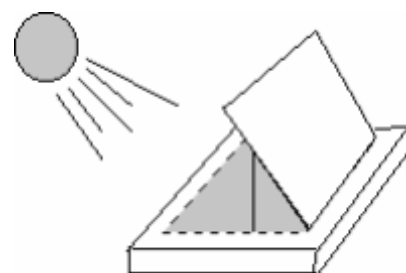


Diagram 4

- Close the pizza box top (window), and prop open the reflecting flap of the box with a wooden dowel, straw, or other device and face towards the sun.
- Adjust the reflecting flap until the aluminum reflects the maximum sunlight through the window into the oven interior.
- Your oven is ready! You can try heating s'mores, English muffin pizzas, or hot dogs, or even try baking cookies or biscuits. Test how hot your oven can get, using two thermometers, one inside and one outside the pizza box.



Pizza Box Oven Summary

Name: _____

BLM 2.3b

Names of Group Members: _____

Special Materials Used: _____

Observations

Questions

What worked well in your design? _____

In what ways could you change or redesign your model to increase the temperature?

2.4

Time: 2 hours

The Urban Heat Island Effect: Analyzing Temperature Maps

BLMs

BLM 2.4a
The Urban Heat Island

BLM 2.4b
Urban Planning

Overview

Students will study the patterns of urban development as seen through the lens of a temperature map. Since urban areas are hotter than their surroundings, students can use a temperature map to identify major cities within a two-hour radius of Toronto. See map on back cover of this guide.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred Specific ■ assess the environmental and economic impacts of using conventional and alternative forms of energy ■ describe the role of radiation in heating and cooling the earth, and explain how greenhouse gases affect the transmission of radiated heat through the atmosphere ■ identify common sources of greenhouse gases and describe ways of reducing emissions of these gases
Science and Technology: Interactions in the Environment	■ investigate interactions within the environment, and identify factors that affect the balance between different components of an ecosystem
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

Planning Notes

Read the following background information and the BLMs. Study the laminated poster to familiarize yourself with the location of various cities.

Background: Heat Is Everywhere

Energy is essential for changing a system from one state to another state. Changes can be visually obvious, like a change in position, or they can be invisible, like a change in pressure or temperature. Here are two simple examples: It takes energy to move a box 1 metre to the left. It also takes energy to change the temperature of the box from 10°C to 20°C, or from 40°C to 37°C. We build devices that use energy to make these kinds of changes for us. Unfortunately, we will never be able to build a perfect device that uses all of the energy we provide it without some degree of waste. Whenever we use energy to do work, some of the energy will be wasted as heat.

Systems, both mechanical and biological, have elaborate built-in or designed mechanisms to get rid of waste heat. These mechanisms become most apparent to us when they fail. For example, when someone forgets to drink sufficiently, the mechanism of cooling off by sweating stops working. If the cooling system of a car malfunctions, the car breaks down from overheating.

No system is completely “efficient.” All systems produce some waste. But, you might ask: When a child rides a bike, leg muscles do work to move the pedals. This work causes a change in position of the bike. As a system, where is the waste? The waste appears as heat in many different ways. Whenever mechanical parts move against each other, there is some waste heat produced. Where the wheels rub against the road, there is waste heat. And the child too produces waste heat as the child's body gets hot from the activity. All the waste heat is released to the environment.

A major goal in energy conservation is to design our devices for efficiency—so that they use as little energy as possible to perform the functions they are designed for. We need to pay close attention to how the devices produce waste heat. Why the concern? Climate change.

Climate change means that the temperatures are changing around the globe. This will cause changes in ecosystems—which will affect humans. For example, if our summers become hotter, we will use air conditioning more often, which will increase the pollution from coal-fired plants used to supply the necessary electricity. It also means our energy bills will be higher. Another effect is that at higher temperatures, soil does not hold onto its moisture as well, so soils will be drier. Drier soils mean it will be tougher on plants and trees seeking water that is needed to help keep them cool. Our crops will be affected, and the vegetation that helps keep the planet cool and that feeds animals, will be threatened. The effects of global temperature increases are widespread and serious.

Prior Knowledge

- knowledge of satellite images: photographs of the Earth taken from high in space by satellites. Sensors can detect information such as elevation, topography, and weather systems. Infrared satellite images can detect the temperature of land and sea surfaces.

Teaching / Learning Strategies

1. Show students the kit's laminated poster called “Temperature Map of Southern Ontario.” Have them locate Toronto on the map. Ask students about the various colours on the map and what they represent. Ask why they think some areas are hotter than others. Remind students of their previous study of the urban heat island effect, in Activity 1.3: Mapping the Classroom and School Ground and Activity 1.4: An Excursion to Exhibition Place (if you did those two activities).

2. Ask students to locate various cities in southern Ontario on the map, such as Brantford, Woodstock, Guelph, Kitchener-Waterloo, Cambridge, Milton, Hamilton, Burlington, Oakville, Mississauga, Etobicoke, Toronto, Alliston, Orangeville, Brampton, Pickering, Ajax, Oshawa, Markham, Aurora, Newmarket, Uxbridge, Bradford, Richmond Hill, Scarborough.
3. Present BLM 2.4a: The Urban Heat Island either as an individual handout or on display for the whole class. Read the BLM out loud while students follow along, explaining any challenging vocabulary as you go. Draw students' attention to the graph and ask them some questions about it, such as the following:
 - What is the lowest temperature on the graph, and in what type of area does it occur?
 - Why is the temperature lower in that area?
 - In what area is the temperature the highest? Why?
 - What does a “commercial” area look like? How does its temperature compare with the downtown area? What are some reasons for the difference?
4. Ask students to complete BLM 2.4b: Urban Planning individually or in pairs. Afterward, have students share their designs and ideas and explain the reasoning behind their decisions in terms of heat absorption and reflection.

The Urban Heat Island

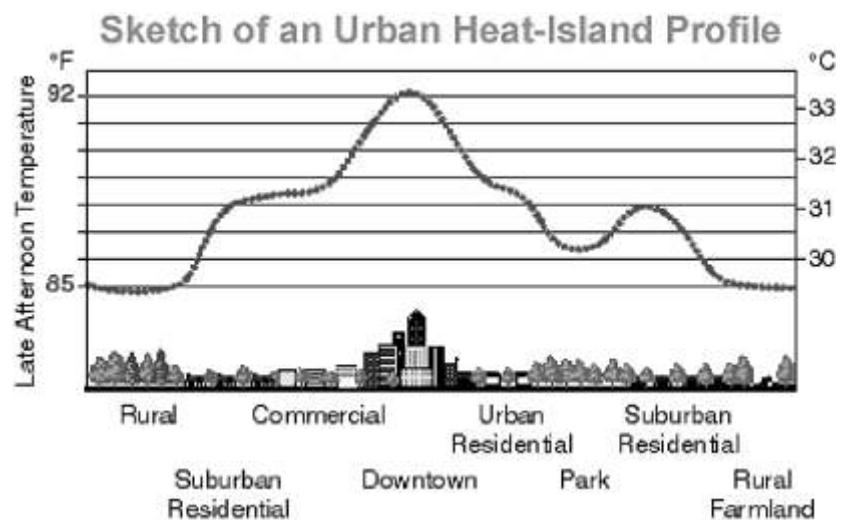
Name: _____

BLM 2.4a

What is the urban heat island?

The graph below shows how human cities affect the temperature of the local environment. Notice that right above the most developed part of the city, the temperature is about 33°C . The temperature outside the city is 29°C . The idea of an island is a metaphor for cities—but instead of being surrounded by water, cities are surrounded by cooler areas. For this reason, we say that cities are urban heat islands.

Heat islands develop in cities when naturally vegetated surfaces are replaced with asphalt, concrete, rooftops, and other artificial materials. The artificial materials store the sun's energy during the day and remain hot long after sunset. This makes air temperatures over a city much higher than air temperatures over nearby rural or suburban areas.



http://www.cleanairpartnership.org/cool_toronto_urbanprofile_large.htm

Is this a negative thing?

Yes! Higher ambient (surrounding) air temperatures make heat waves worse. Higher temperatures also speed up the chemical reactions that produce smog. This in turn increases suffering by people with respiratory problems, and increases health costs. In addition, the warmer a city is in the summer, the greater the demand for air conditioning, which increases the amount of electricity used. Energy costs go up, and to meet growing demand, power plants must increase their use of fossil fuels, which has a negative impact on air quality and leads to climate change.

The Urban Heat Island (cont'd)

BLM 2.4a

What can we do to counteract the urban heat island effect?

1. We can promote the use of cooler surfaces and shade trees.
2. Cities can be cooled by creating strategically chosen areas where plants are grown. Trees and other vegetation can shade buildings, pavements, parking lots and roofs, and naturally cool a city by releasing moisture into the air through evapotranspiration.
3. By protecting buildings from wind, trees can reduce heating costs in winter, and through direct shading and evaporative cooling, can contribute to reductions in air conditioning use in summer.
4. The use of reflective surfaces such as light-coloured roofs, roads, and parking lots are another way to cool cities. Light-coloured surfaces reflect rather than absorb heat. The more solar radiation a surface absorbs, the hotter it gets. The more radiation it reflects, the cooler it stays, and cooler surfaces can be achieved with little or no additional costs.
5. Strategically placed areas of vegetation and the use of reflective surfaces will not only help cool cities during summer months, but also lower energy bills by reducing energy use (a hot roof translates into much higher air conditioning costs). This in turn reduces greenhouse gas emissions and ultimately improves air quality.

What is the link between the urban heat island effect and air quality?

Smog is a photochemical reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). NO_x and VOCs react in sunlight and produce smog. The reaction rate is highly temperature-sensitive. The hotter it gets, the more quickly smog forms. By lowering ambient air temperature, it is possible to slow the process of smog formation and improve air quality.

Why should we make efforts to combat Toronto's urban heat island effect?

According to scientists, climate change will result in more frequent and extreme weather events such as summer heat waves. These effects will be made worse in urban areas, where concrete and pavement re-radiate heat. We need to develop adaptation strategies to address the impacts of climate change.

Reducing the effect of the urban heat island is one such adaptive action. By reducing the urban heat island, we will have: cleaner air; cooler, more comfortable temperatures in the summer; and we save energy, as well as money.

Urban Planning

Name: _____

BLM 2.4b

Date: _____

- Imagine you have been asked to build an office building in downtown Toronto. You want to plan the building and its site carefully so that it does not contribute to the urban heat island effect.
- Draw your plan for your building and its location site. Label what you have done to help “keep it cool.” Consider the elements listed below. Refer to the reading “The Urban Heat Island” for more information.

rooftop • parking lot • driveways • trees • vegetation • walkways • surfaces
height of building • ground cover • construction materials • wind



2.5

Time: 1-2 hours

Surfaces: Metal Foils

Overview

This activity experiments with different types of metal foils to see what types of surfaces absorb radiant energy. The infrared sensor and the EasySense Data Logger are used to collect and record the data. In this investigation, several pieces of metal sheets that have different types of surfaces—polished, matte, glossy paint, black paint—are used. The investigation is to see if the energy that comes off the sheet is due to its temperature or its type of surface. The metal sheets are placed the same distance from a radiant energy source and allowed to heat up. The temperature of the sheet and the energy it re-radiates are measured.

Curriculum Connections

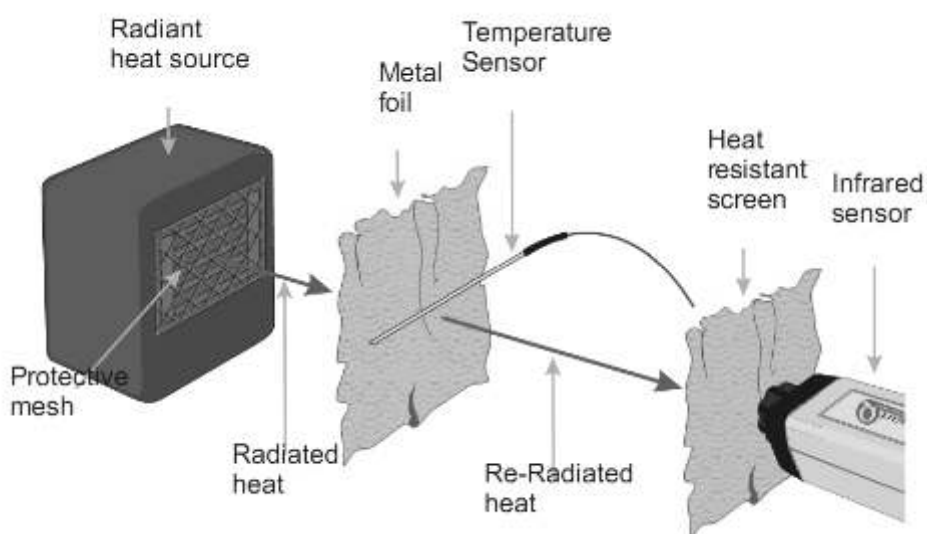
Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ investigate ways in which heat changes substances, and describe how heat is transferred ■ demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within the earth's systems Specific ■ explain how heat is transmitted through radiation, and describe the effects of radiation from the sun on different kinds of surfaces ■ use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation ■ use appropriate science and technology vocabulary
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

Planning Notes

Materials

- ◆ EasySense Data Logger
- ◆ infrared sensor
- ◆ temperature sensor
- ◆ radiant heat source with protective mesh
- ◆ foil-covered shutter or a heat resistant screen
- ◆ several metal foils finished in different ways: polished metal, painted with black gloss paint, painted with black matte paint
- ◆ tape to secure the temperature sensor to the metal foil
- ◆ ruler

Read through the instructions and gather the equipment needed.



Prior Knowledge

- use of the EasySense Data Logger and sensors
- safety in using hot objects

Teaching / Learning Strategies

Following are the steps of the experiment. You may want to conduct the investigation as a demonstration, or have selected students do so.

1. Connect the infrared and temperature sensor to the EasySense Data Logger. (The Data Logger does not need to be connected to a computer.) Check to make sure the silica glass filter in the end cap of the infrared sensor has been removed.
2. Set up the apparatus as shown in the diagram above. Each of the metal foils will need to be placed at the same distance from the radiant heat source. The infrared sensor will need to be kept at the same distance from the metal foil. The distance that the infrared sensor can be from the metal foil will depend on the size of the metal foil.

The target area of the sensor is the same diameter as the distance. For example, if the infrared sensor is 15 cm from the foil then it will detect from an area of about 15 cm in diameter (so the test surface of the foil must be more than 15 cm in diameter, e.g., 20 cm). The infrared sensor should be placed so it does not receive any heat from the radiant heat source—only from the metal foil.

3. Tape the temperature sensor to the first metal foil.
4. Turn on the radiant energy source and allow it to reach its operating temperature. Make sure the shutter is stopping radiant energy from reaching the infrared sensor.
5. Place the first metal foil to be tested between the radiant heater and the shutter, so it is being warmed by the heater.
6. Start the EasySense logger and select Snapshot from the Home page.
7. Click on Start. Remove the shutter from between the sensor and the foil and left-click in the graph area to record the value. Place the shutter back between the sensor and the foil.
8. Replace that foil with a different foil (in the same position, with a temperature sensor attached) and wait 2–3 minutes for it to reach temperature.
9. Remove the shutter to record the next value.
10. Repeat until all foils have been tested. Stop the data recording.
11. Use Add Text to label each value with the foil that produced each result and then Save.

Results and Analysis

The bar chart will show two bars for each foil: one will show the temperature of the foil, and the other will show the energy being radiated off the back surface of the foil. Place the information from the graph in a table as shown in the following example.

Description of surface facing the radiant heat source	Description of the surface facing the infrared sensor	Temperature on the foil ($^{\circ}\text{C}$)	Radiant energy from the foil ($\text{W}/\text{m}^2 \text{sr}^{-1}$)
polished metal	black paint		
black paint	polished metal		
matte paint	gloss paint		

Data

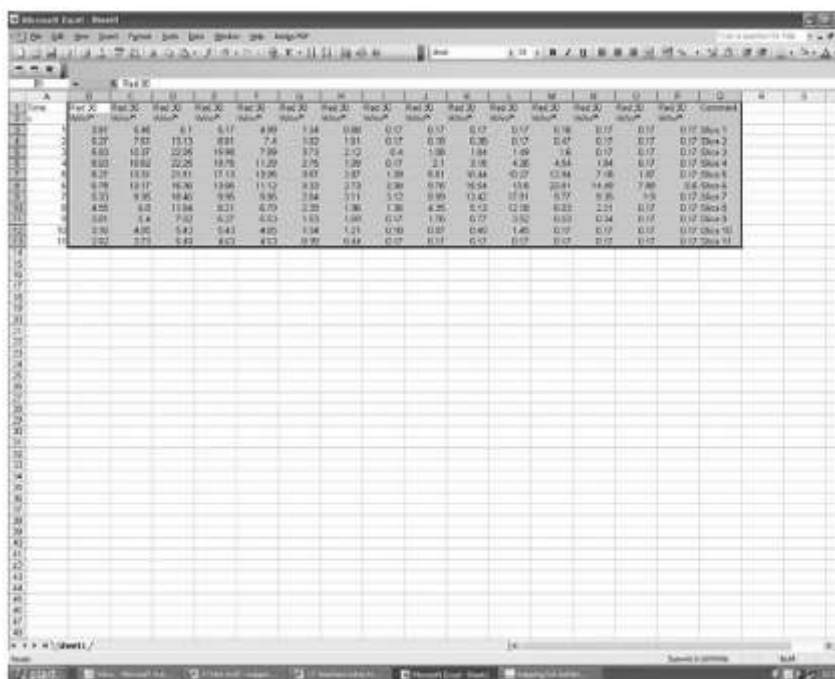
At this point the data will look confusing, but as long as the data has been recorded in data sets that correspond to a grid column, all will be revealed as the analysis continues.

Use the File, Transfer to Excel command to open Excel and place the data into Excel.

For a quick reveal of the data, in Excel highlight all the data (except the reading number column).

Click on the Chart icon and select the 3D Surface chart (the exact name and location in sub menus will vary with editions of the software).

Data Selected for 3D Surface Chart



Source: Data Harvest

12. To conclude the lesson, have a class discussion based on the following questions.

- What type of surface let the foil become hottest?
- What type of surface let the foil stay coolest?
- Which type of surface facing the infrared sensor showed the most radiant energy?
- If you were to design a heat-protective shield for a firefighter, what type of surface should face the (a) fire or (b) the firefighter?
- What type of surface would you coat a building with to keep the heat out?
- What type of surface should a building have if it is to absorb heat from sunlight? What surface should be inside to transfer heat into the space inside the building?
- Why is the inside of a thermos silver or white?

2.6

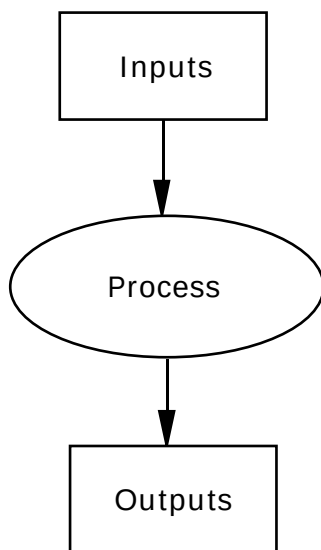
Time: 2-4 hours

Life Cycle Analysis: Embedded Energy

Overview

This activity has students consider the environmental impacts of product manufacturing and the energy inputs that manufacturing entails. In three related tasks, students explore life cycles by studying the kit's three laminated posters on life cycles of products. They research the life cycle of another product. They also make paper, to get hands-on experience in the cycle of a product.

Background



To understand the impacts of manufacturing products more clearly and to see how much energy is needed, students will learn that the most basic pattern of making anything can be described in terms of the *inputs* and *outputs* required. In reviewing the 3Rs, students will learn that when they save product materials (matter inputs) they are also saving energy inputs at every stage of the manufacturing process. The energy needed to make a product can be considered to be embedded in each stage of its making—hence the term *embedded energy*. Students will focus on energy inputs or embedded energy as they become familiar with life cycle analysis by studying the life cycle posters of a soccer ball, a cell phone, and a DVD.

The students then apply their learning through researching the life cycle of another product. Students become equipped to transform their new knowledge into a 3Rs information campaign for promoting general understanding of what is involved in making the stuff around us, directed at one or more audiences in the school. Or it could be used more specifically to promote their school's greening efforts.

The experiential dimension of learning about energy inputs or embedded energy will come through having the students make paper. We know that paper comes from trees, but how does it get from one form to the other? Students will learn more about paper-making through making it, and then reading a short article about one of the fibres found in wood. The focus is quite deliberately on the energy required to make the paper.

The order in which these learning activities take place may not be strictly linear. The paper-making may occur over time as the other activities are pursued.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred ■ demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within the earth's systems Specific ■ assess the environmental and economic impacts of using conventional and alternative forms of energy ■ describe the role of radiation in heating and cooling the earth, and explain how greenhouse gases affect the transmission of radiated heat through the atmosphere ■ identify common sources of greenhouse gases and describe ways of reducing emissions of these gases
Science and Technology: Interactions in the Environment	■ investigate interactions within the environment, and identify factors that affect the balance between different components of an ecosystem
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

BLMs

BLM 2.6a
No Fish Story!: The Making
of an Aluminum Can

BLM 2.6b
What Is Embedded
Energy?

BLM 2.6c
Lignin? Yeah, Lignin!

BLM 2.6d
Matter and Energy: Tracing
a Product's Life Cycle

Planning Notes

- Read over the lesson and the BLMs. Decide on the student groupings for the various activities. Make copies of the BLMs.
- Note that the paper-making activity can be spread out for several days, or even weeks as students discover the process and work it requires.
- Gather the materials and look at the suggested websites for any additional resources. Find a source of wood chips and recycled paper to prepare 8–10 large ziplock bags, depending on your class size. Half the bags should contain only wood chips, and the other half should contain only recycled paper. Make sure that the bags have roughly the same mass.

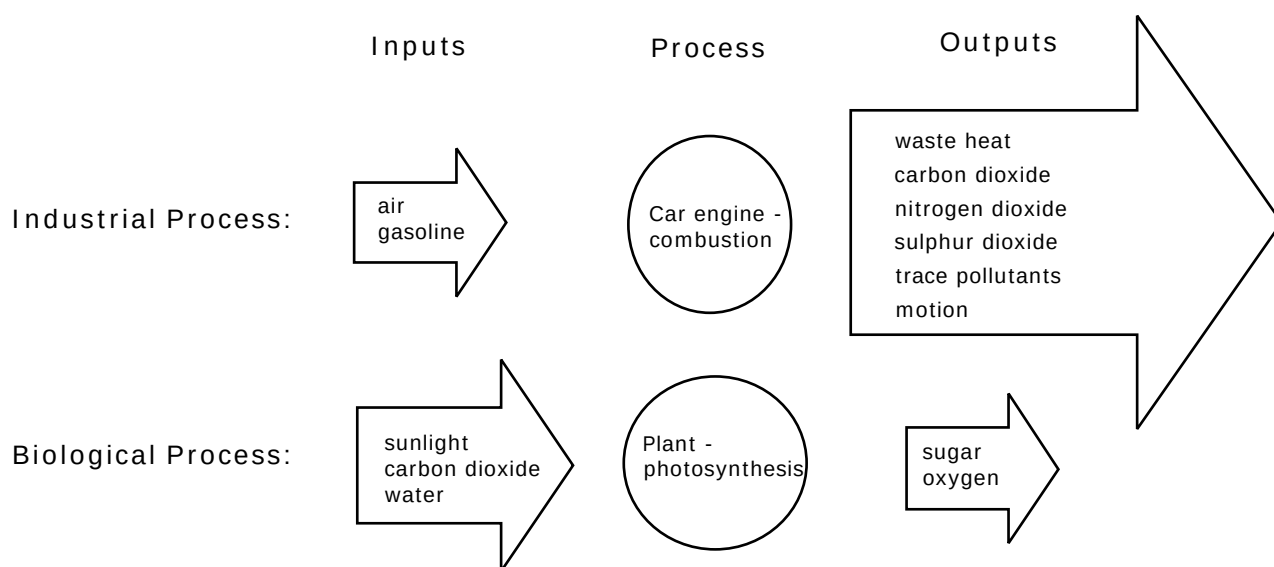
Prior Knowledge

- understanding of the terms *consumption*; *life cycle*
- review of the 3Rs

Teaching / Learning Strategies

PART ONE: Product inputs and outputs

1. Teach students the words *input* and *output*. Focus on a product familiar to students such as bread or a chocolate chip cookie. Ask students to list
 - the inputs (ingredients of the baked good)
 - the method of manufacturing (baking, which uses fuel, and requires an oven, made mainly of metal)
 - the outputs (waste heat, waste water [from washing], and the baked good for consumption)
2. Help students understand input-output diagrams that allow them to compare an industrial process to a natural process. Use visuals and charts such as on the following page.



Industrial Processes	Biological Processes
Need (inputs) • high temperatures • high pressures • a lot of energy and water	Need (inputs) • everyday temperatures • everyday pressures • free sunlight and small amounts of water
Produce (outputs) • a lot of waste heat • a lot of solid, liquid and gas wastes	Produce (outputs) • no pollution • no wastes

PART TWO: Learning about product life cycles

1. Display BLM 2.6a: No Fish Story!: The Making of an Aluminum Can and use it to explain the basic process of making an aluminum can. Emphasize that fact that between each stage, there is consumption of fossil fuels for transportation, since each manufacturing stage occurs in a different place. Most of the damage to Earth is done at the first two stages: mining the bauxite and processing the ore. At each stage, energy, water, and chemicals are inputs. At each stage, waste water and waste heat are outputs.

Materials

- Life Cycles Posters:
Cell Phone, Soccer Ball,
CD/DVD
- wood chips (from
garden centres,
hardware stores;
enough for 4–5 large
ziplock bags)
- recycled paper (enough
for 4–5 large ziplock
bags)
- materials for making
paper (see Part 3,
Step 2)
- various tools for
crushing wood chips
(hammers, mortar and
pestle)
- goggles
- Material Fact Sheets
from Recycling Council
of Ontario –
<http://www/rco/on.ca>
- City of Toronto Works
and Emergency
Services – <http://www.toronto.ca/garbage/Waste>
- Minimization Standards
of the TDSB – <http://ecoschools.tdsb.on.ca>

2. Post the three laminated posters in accessible locations in the classroom. Invite students to scan all three posters, moving in groups from poster to poster. Then assign pairs or small groups of students to study each poster more closely. One group could use the aluminum can life cycle instead of a poster. As a way to focus their thinking on the energy embedded in these products, have them complete BLM 2.6b What Is Embedded Energy? with their partner or group. Have them compare their responses with a another pair or group.

PART THREE: Making Paper Takes Energy!

1. Tell students that they are going to learn first-hand about the energy involved in making paper.
2. Explain to students that you want them to think about how they can make their own paper from scrap material. In this section, explain that some groups will receive wood chips, and that others will receive recycled paper. Treat their ideas seriously as they brainstorm how to achieve the end result. Let them carry out their plans as far as possible and ensure their safety at the same time. This might be done over several days, or even weeks. This activity has the potential to change the way students think about paper for the rest of their lives. Anticipate the kinds of materials and tools that students might need, for example, hammers for crushing, blenders for mixing, water for mixing, rollers, trays for drying. The point is for students to feel how much energy is required to mash up pieces of wood. Realize that usable paper will likely not be a product of students' efforts.
3. When students have finished their paper-making efforts, display and read aloud BLM 2.6c: Lignin? Yeah, Lignin! The information furthers their understanding of why paper production is so energy-intensive. Then have students work in pairs to interview each other about the paper-making process and how successful they were. As part of the interview, students should ask whether the process has made them think differently about paper. As an alternative to the interviews, you could have students write about the experience in a paragraph, journal entry, or comic strip.

Reducing paper consumption reduces the need to cut down trees. Therefore less energy is expended in cutting the trees, finishing the wood, and shipping it to market. Those spared trees create habitats for birds and insects, prevent erosion by holding soil in place with their roots, and slow the winds of a changing climate.

Making paper from recycled paper uses about 75% less energy and 50% less water than making paper from wood. Basically, the recycled paper is already in place where it needs to be, so fuel for transportation is saved. Also, recycled paper is already processed. It is much easier to shred and whiten recycled paper than to process wood, which is hard, and contains other fibres such as lignin that need to be removed.

PART FOUR: Researching the Life Cycle of a Product

1. Distribute BLM 2.6d Matter and Energy: Tracing a Product's Life Cycle to partners or small groups and have them research a product of their choice. The activity will help solidify their understanding of matter and materials, how energy is part of the production process, and their own awareness of these processes.

PART FIVE: Review the 3Rs

1. To conclude this series of activities, have a class discussion about the meaning of the 3Rs so that students understand the connection between each "R" and matter cycles and energy flows.

Reducing the number of products that we purchase means we save not only materials (matter) but also the energy that is embedded in them. This reduces the energy and materials extracted from the Earth, and also reduces the fuel used to transport the energy and materials. Before purchasing an item, it is important to consider whether or not the item is really needed.

Reusing items rather than buying new items every time also reduces the need for new items. Purchasing used items for yourself or donating your used items to organizations that will reuse them is a good way to reduce the need for producing new items, thus saving both materials and energy.

Recycling is an industrial process that uses energy. So this "R" involves the least savings of the three. Making products using recycled instead of new materials conserves energy. It is important to be aware of the growing number of materials that are being collected for recycling in one's community.

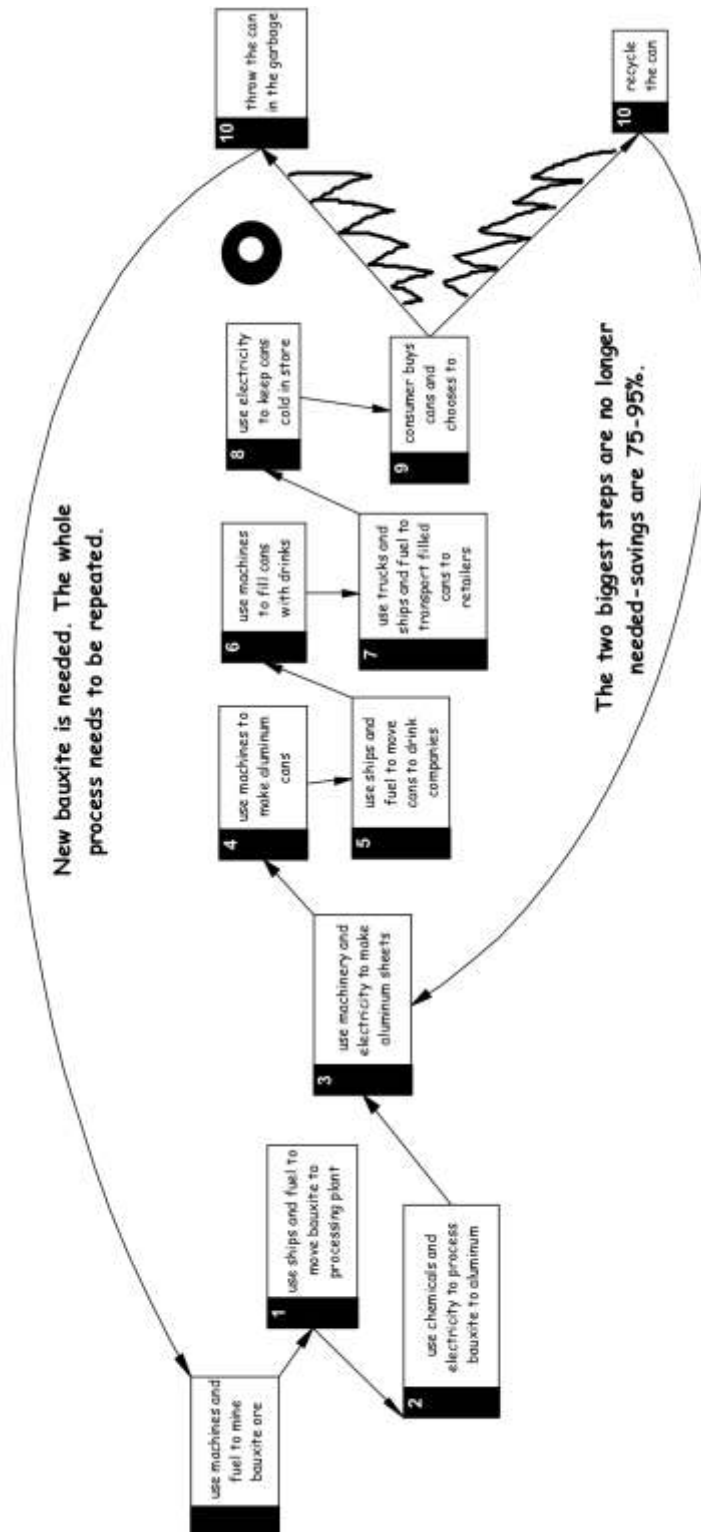
Saving paper that has been used on only one side for re-use is a small but important way to save paper in the classroom.

2. With the class, generate a list of questions related to the 3Rs for discussion and further research. For example,
 - Why do we need to reduce our energy consumption?
 - Who should recycle?
 - What kinds of products can be recycled?
 - Why do we need to reduce our use of paper?
 - What does 30% recycled paper mean? What does 100% recycled paper mean?
 - Why do we need to reduce our purchase of plastic products?
 - What are toner cartridges? What are they made of?
 - How can they be reused?

No Fish Story!: The Making of an Aluminum Can

Name: _____

BLM 2.6a



What Is Embedded Energy?

 Name: _____ **BLM 2.6b**

When you buy a product, you are not only buying the materials used to make the product. You are also actually (buying) all the energy that was used to make and assemble the parts of the product, as well as the energy used to transport all the parts and final product to the store. The energy that you are buying is called *embedded energy*.

For the product life cycle that you were assigned, brainstorm the forms of energy that may have been used at the different stages in the life of your product. Record the forms of energy in the chart below. Remember, at each stage of every process, waste heat is an *output*.

Groups Members: _____

Check the product you were assigned: ☐ Soccer Ball ☐ CD or DVD ☐ Cell Phone

Stage	Energy Input	Energy Output
1		waste heat
2		waste heat
3		waste heat
4		waste heat
5		waste heat
6		waste heat
7		waste heat

Lignin? Yeah, Lignin!

Name: _____

BLM 2.6c

Highlight these words when you read them: plant cell, cell wall, cellulose, lignin, fibres, pulp, durable, energy-intensive, organic compound.

The building blocks of plants are plants cells. Plant cells are very different from animal cells. Plants don't have bones, but their structures are able to support a lot of weight — just think of a sunflower stem — what makes the stem so stiff? The answer is found by looking carefully at plant cells. They are surrounded by a thick cell wall. Two important fibres found in the cell wall are cellulose and lignin.

Lignin is the second most abundant organic compound on Earth after cellulose. Lignin makes up about one-quarter to one-third of the dry mass of wood.

Lignin provides the cell wall with a lot of strength. It also plays an important role in forming vessels or tubes that allow water to reach the tops of trees through the trunk from roots in the ground. Lignin does not break down easily. It makes wood durable, and protects trees from fungus and bacteria. This is great news for trees, but bad news for some papers. When lignin is left in paper, the paper changes colour pretty quickly. Newsprint usually contains lignin — and newsprint changes colour when exposed to sunlight. So in order to make many kinds of paper, the lignin must be removed — and this requires a lot of energy and a lot of special chemicals.

So wood is mashed up into a pulp and chemically treated to remove the lignin. It is then washed away to leave paper-friendly fibres such as cellulose, from which the paper is made. Recycled fibres do not need to be treated for lignin — the lignin has already been removed, so a gentler process (less energy-intensive) is all that is needed to break the fibres apart. And they can be broken apart about a dozen times before they are too short to make into more recycled paper.

Matter and Energy: Tracing a Product's Life Story

Name: _____

BLM 2.6d

Here are some guiding questions to help you to organize your information from your research. Include any other interesting information you discover in your research.

1. What product (matter) have you chosen to learn more about?

.....

.....

2. What natural resource or raw material is needed to make this product?

.....

.....

3. Where is energy needed in the life cycle of this product?

.....

.....

4. What is the effect of taking this raw material from the environment?

.....

.....

5. Can this product be recycled? How is it done?

.....

.....

6. What is the recycled product made into after recycling? What are benefits of recycling this product?

.....

.....

2.7

Time: 1-3 hours

Exploring Canadian Winds

BLMs

BLM 2.7a
Winds of Canada

Overview

This activity relates to the Exhibition Place Turbine Tour and builds upon what students have learned and experienced about wind energy. If you took the tour in Activity 1.4 An Excursion to Exhibition Place, you can review the experience at this point with students, or you could arrange a visit now. Also, details about the turbine can be found at the website listed under Materials on the next page. Students study state-of-the-art modelling software that displays a map of Canada and the wind speeds in different locations of the country. Using the site, they focus on southern Ontario and create a colour legend for a map to show the wind speeds.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment Specific ■ assess the environmental and economic impacts of using conventional (e.g., fossil fuel, nuclear) and alternative forms of energy (e.g., geothermal, solar, wind, wave, biofuel)
Science and Technology: Interactions in the Environment	■ assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts
Geography	■ describe how humans acquire, manage, and use natural resources, and identify factors that affect the importance of those resources ■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes ■ generate, gather, and organize ideas and information to write for an intended purpose and audience
Mathematics	■ make and evaluate convincing arguments, based on the analysis of data

Materials

- ◆ physical map of Canada
- ◆ computer lab
- ◆ pencil crayons for colouring in the map
- ◆ website:
<http://www.trec.on.ca/reeducation/tours.html>

Planning Notes

- You will need to judge the timing of these activities with respect to your math program and the possible field trip to the wind turbine at Exhibition Place.
- Prepare copies of BLM 2.7a: Winds of Canada to provide students with experience using a computer model.
- Arrange for time at your computer lab. Students could work in pairs for the activity.

Prior Knowledge

- understanding of function of wind turbines
- construction of bar graphs
- navigating a website
- understanding of “mean” in data

Teaching / Learning Strategies

1. Present a physical map of Canada to students and explain what it is. Ask them to consider where winds will be highest, and compare this to where populations are highest. Introduce students to the wind speed map at <http://www.windatlas.ca/en/maps.php> to highlight regions of Canada that are windy. Many questions can be posed and answered, based on comparisons such as these:
 - a) *Where do you find the highest winds? Over water, far north, prairies, mountains?*
 - b) *Where do you find the lowest winds? Mountains, boreal forest?*
2. Walk through the features of the wind speed map at the website, and then hand out copies of BLM 2.7a: Winds of Canada. Review the BLM with students and then have them proceed. Circulate to assist with any challenging vocabulary and to monitor progress.

To engage students more immediately in these discussions, point to their real world application. Consider having students search for recent local media coverage of wind farms and where they should be sited (e.g., off Scarborough Bluffs, Wolf Island). This can lead to a lively debate about something close to home.

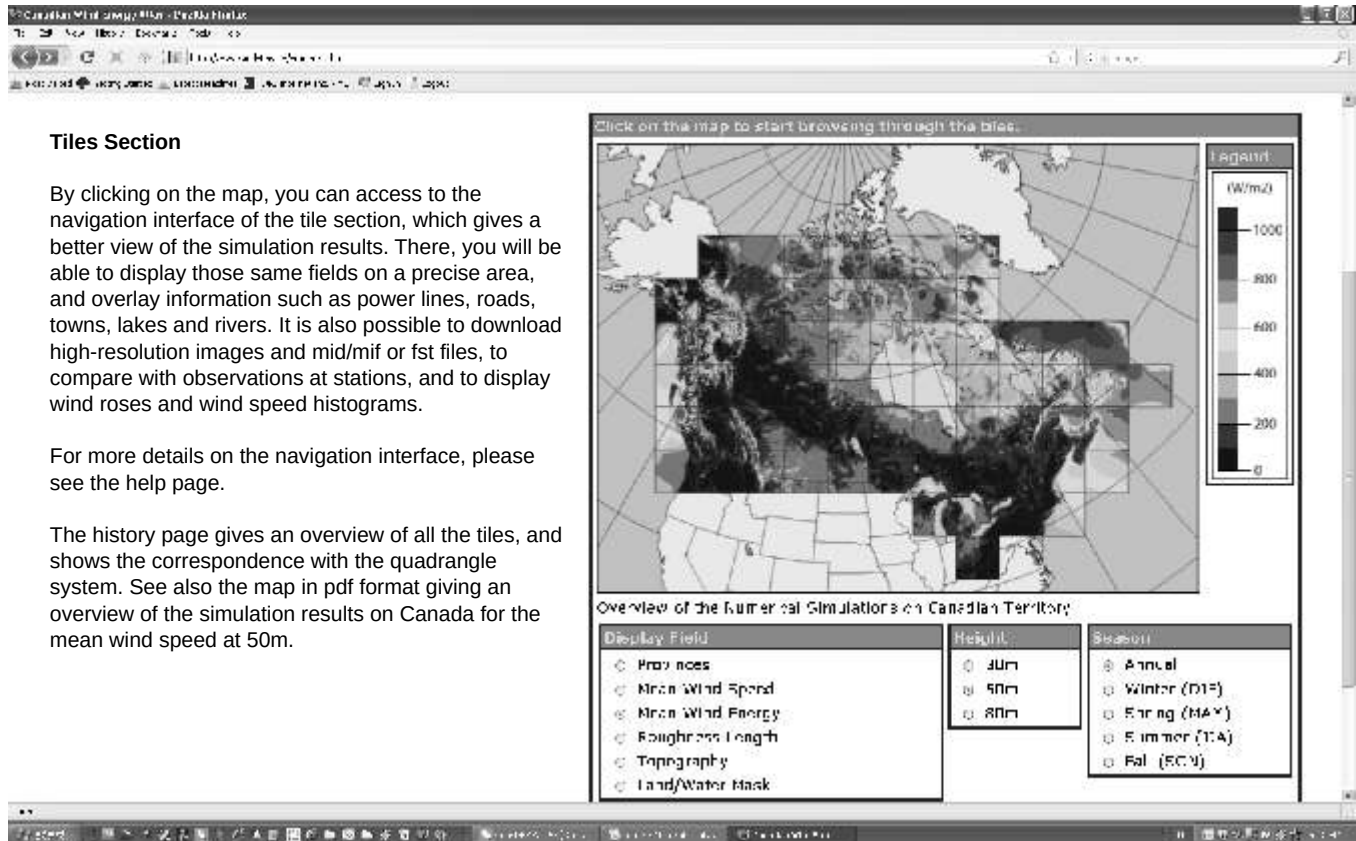
3. To conclude the activity, invite students to share ideas that arise from their exploration. Starter questions could include: Where in southern Ontario could wind farms be located? What features make these areas suitable for wind farms? Should local citizens have an opportunity to be part of any decisions being made about the construction of wind farms?
4. Encourage them to conduct further research into wind energy. You could use one of the following ideas:
 - Invite students to write a journal entry in role as a citizen of the future—their writing should incorporate their predictions about what type of energy is being used.
 - Have students create an advertisement for wind energy.
 - Have students role-play a scenario in which a community debates the construction of wind turbines in their area.

Exploring Canadian Winds

Name: _____

BLM 2.7a

The Canadian Wind Energy Association has developed a program to show people what wind looks like across Canada. Visit the website <http://www.windatlas.ca/en/maps.php> to complete this assignment. You are at the right site when you see the image below.



1. Find the Display Field, and then click on the Provinces button.

Click back and forth between the Mean Wind Speed and the Provinces buttons. Study the legend of colours so you can figure out the wind speed changes in different parts of the country.



Exploring Canadian Winds (cont'd)

BLM 2.7a

a) Which provinces have the highest winds?

b) Why do you think these provinces have the highest winds?

c) Which province has the lowest winds?

d) Where do you expect to find the most wind turbines in Canada? Why?

2. Find the cell that shows southern Ontario by looking for Lake Ontario and Lake Erie.

a) Click on the cell to expand it.



Exploring Canadian Winds (cont'd)

BLM 2.7a

- b) You should now see several windows. Locate the windows listed below, and explain what they allow you to do.

Navigation: _____

Display Field: _____

Height: _____

Display Options: _____

- c) The Height buttons allows us to ask the question: How does the wind change at different heights? Use the Height buttons to explore this question and then record your observations below.

- d) Think about the kinds of questions that the Display Field buttons and Display Option buttons allow you to ask. Brainstorm 3-4 questions with a partner. Write down one of the questions below, and then answer it by studying the changes in the map.

Question: _____

Answer: _____

3. Make sure that your map is set back to southern Ontario.

- a) Set the Display Field to Mean Wind Speed.

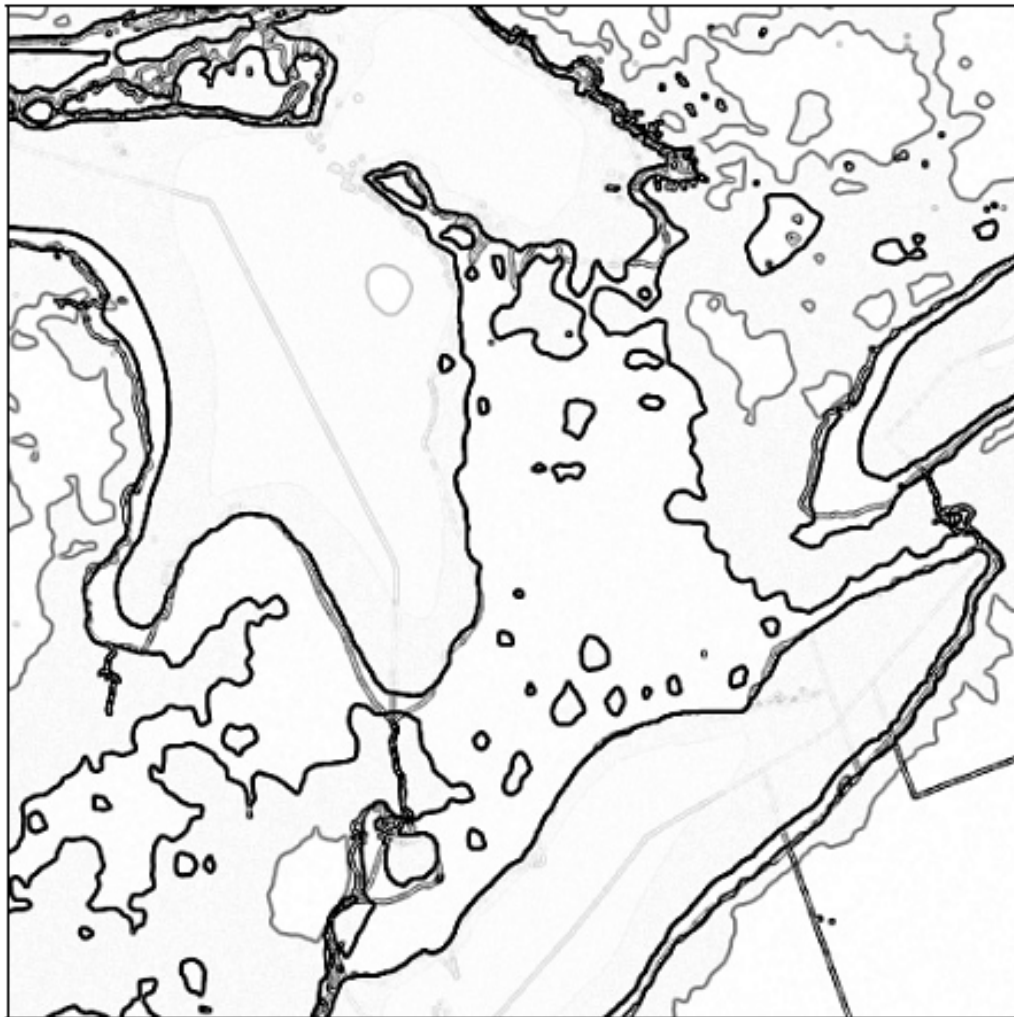
What is a synonym for "mean"? _____



Exploring Canadian Winds (cont'd)

BLM 2.7a

- b) Select a title for your map. Study the legend, and then colour the map below to show how the wind speed changes across southern Ontario. Simplify the map so you will have fewer colours than shown in the legend. Draw your own legend beside the map.



- c) What are the best places to build wind turbines in southern Ontario? Besides wind speed, what other reasons need to be considered before building a wind turbine?

Section 3: Education *for* the Environment

Activity 3.1
Why Insulate Houses?

Activity 3.2
Energy Conservation in the Classroom

Activity 3.3
Energy Conservation: Selecting a Light Bulb

Activity 3.4
Using the EcoSchools Program

3.1

Time: 1-2 hours

Why Insulate Houses?

BLMs

BLM 3.1a
Logging Sheet

BLM 3.1b
Analyzing the Data

Overview

Students will learn that a well-insulated house should be able to be kept warm in winter and cool in summer with very little additional energy expenditure. In this experiment, the temperature of an enclosed space is measured every 30 seconds for 5 minutes as heat from a small incandescent bulb is added. After the heat source is removed, the temperature is measured for a further 5 minutes to see how the space loses heat. The use of a light bulb to heat the “house” is useful as it teaches that tungsten filament lamps are a source of heat.

The first test “house” is a simple cardboard box with visible gaps in the joints. Students then construct another “house” that has insulation to investigate how energy loss from enclosed spaces can be reduced, and if insulation helps slow down the rate at which heat energy leaves or enters the house.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment Specific ■ assess the social and environmental benefits of technologies that reduce heat loss or transfer (e.g., insulated clothing, building insulation) ■ follow established safety procedures for using heating appliances and handling hot materials ■ use technological problem-solving skills to identify ways to minimize heat loss ■ use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation
Science and Technology: Interactions in the Environment	■ assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts. ■ use speaking skills and strategies to communicate for a variety of purposes

Materials

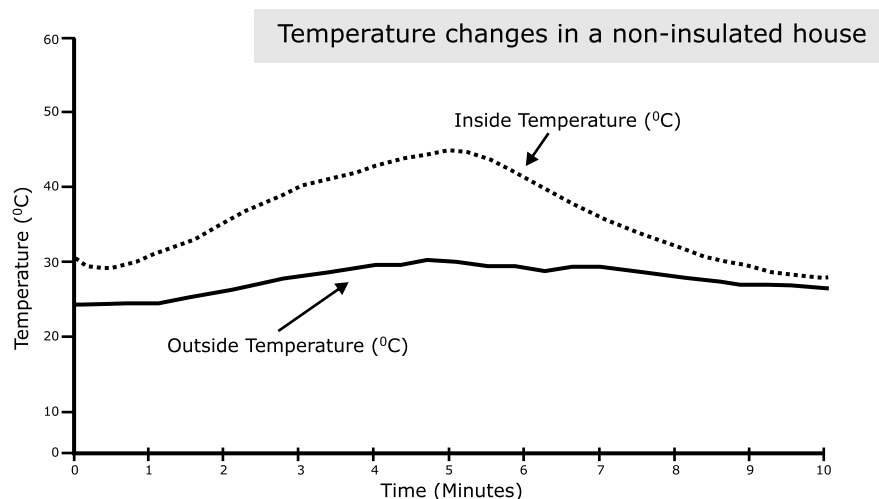
- ◆ EasySense Data Logger
- ◆ stopwatch if using Meter Method of logging
- ◆ computer and EasySense cables if using EasyLog method
- ◆ temperature sensors
- ◆ retort stand and clamps
- ◆ identical large boxes (15x12x12 cm) with lids
- ◆ low voltage bulbs and power supply (1.5 V bulb powered by one D-cell, or 6 V bulb powered by a 6 V lantern battery, or 4 D-cells in series using a battery holder as shown below.)



- ◆ insulating materials such as Styrofoam, paper, cardboard, bubble wrap

Planning Notes

- Choose your method of data logging. The Meter can be used as a regular thermometer. Every 30 seconds you or volunteer students will have to read the Meter and record your results in a table, and then graph the results. The EasyLog method logs the data to a file which can be retrieved by a computer set up with the EasySense software. This is explained in more detail on the Log Your Data BLM on page 122. Anticipate a graph that looks like the following:



- The first part of the experiment can be done as a whole-class activity, with the teacher demonstrating. Students can then work in groups to design an insulated box. The teacher should conduct the testing.
- Gather the materials needed.
- Plan how to manage class time when you are testing the groups' houses and gathering the data on the Data Logger. You will be testing the houses one at a time, and one group will be observing their data collection. The whole class could all observe all groups' testing and data collecting, or you could have other groups begin a related activity (see Ideas for Further Activities).

Prior Knowledge

- safety procedures for handling hot materials
- understanding of the terms *insulation* and *voltage*

Safety

In your discussion about creating the boxes and while you are conducting the testing, be sure to remind students about the safety procedures you are following for handling hot materials. Also be sure to talk about potential fire hazards.

Do not use an open flame to heat the “house.”

Teaching / Learning Strategies

1. Introduce this activity by saying:
To keep houses warm in winter and cool in the summer, we need to keep the temperature inside the house different from the temperature outside. To do this, energy is used within the house—either to add heat to the house or to remove heat from the house. Unfortunately, not all of this energy is used exactly for this purpose; some of the energy is “lost.” We’re going to look at how insulation helps slow down the rate at which heat energy leaves or enters the house.
2. Ask students to think of ways that heat is created within a house, or ways that it enters or leaves a house. Ideas are: heating, lighting, bodies of the residents of the house, stoves, waste heat from appliances such as dryers, computers, televisions, and from outdoor heat energy entering the house—or indoor heat energy leaving the house!
3. Have a general discussion about insulation. Ask students what they know about insulation and ask them to think of some examples of types of insulation (buildings, houses, clothing, footwear, sleeping bags, animals’ coats, body fat, cooking utensils, beverage cups, picnic coolers).
4. Assign students to groups to insulate a box. In the end, students will see which box kept the temperature the highest after the second 5 minutes of measurement. The design of their box will have to allow for wires to connect to the bulb inside the box, and allow for insertion of the thermometer itself.
5. Create and post a chart like the following and ask the groups to fill in the data for their box. Students can see and compare the results of all the groups’ designs.

Box number	Highest temperature after 5 minutes of warming	Lowest temperature after 5 minutes of cooling	Temperature difference
1.			
2.			
3.			

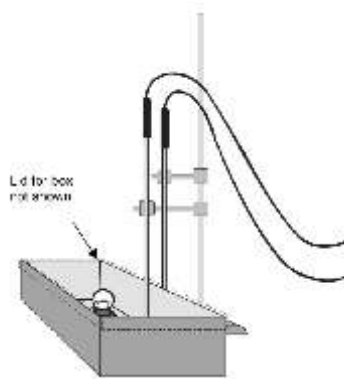
6. Conduct the experiment with the non-insulated house. This is the control experiment for all of the students' experiments. Use a data logging sheet like BLM 3.1a. Assign this as a common graphing task so all students have the control information. While this experiment is running, consider discussing the idea of thermal mass.

Some buildings, such as house trailers, are quite well insulated, but feel as if they get hot and cold quickly. They suffer from having no real mass to absorb heat and then slowly release it later. Homes with thick, dense walls keep a much more even temperature than those built with lightweight (but strong) materials. Heat ponds are ways of compensating for this, e.g., a large water reservoir or brick mass can be placed within the building—it will absorb heat during the summer months and lose heat during the winter months.

7. Have students work in pairs or groups to complete BLM 3.1b: Analyze Your Data. To wrap up the activity, have a class debriefing session. Invite students to discuss the results and state whether they were what they predicted they would be. Ask some questions such as the following:
 - *What type of heat was involved in the experiment: convection, radiation, or conduction?*
 - *Why is it important financially to have well-insulated homes and buildings? Why is it important environmentally?*
 - *What can you do in your own home to be more energy efficient with heating and cooling? (Don't let heat or cool air escape through open windows when appropriate; don't leave the door open; turn down the heat or adjust the air conditioning when not at home; shut blinds and curtains to help insulate)*

Ideas for Further Activities

- Have students find out about various types of home insulation. Which is the most cost-effective method of insulation? What are the pros and cons of the different insulation materials?
- Ask students to monitor and keep track of the number of different types of insulation they observe in one day.
- Have students create a brochure for homeowners to make them aware of the importance of proper insulation. They should include the results of their experiment in the brochure as convincing evidence.



“Log Your Data” Instruction Sheet

- Assemble the apparatus as shown in the diagram. The box is the model of a house, and the bulb represents the heating system. Place one of the temperature probes inside the box and the other near, but not touching, the outside of the box.

Meter Method

1. Provide students with a data logging sheet (BLM 3.1a) and stopwatch. Ensure that students are measuring and recording the temperatures every 30 seconds. After 5 minutes, be sure to turn off the light bulb. Students then continue taking readings every 30 seconds.
2. Ask students to graph both sets of data on the same graph, and then answer the questions on BLM 3.1b.

EasyLog Method

1. Connect the EasySense Data Logger to the computer.
2. Use the Setup Remote function to program the Data Logger to record data for 10 minutes. Consult the software, or manual for instructions if needed.
3. Click on the Start Icon to begin logging.
4. Turn on the light bulb.
5. After 5 minutes, switch off the bulb and continue to log the data for a further 5 minutes or until the recording finishes.

Log Your Data

name: _____

BLM 3.1a

Minutes	Inside Temperature (°C)	Outside Temperature (°C)
0		
0.5		
1		
1.5		
2		
2.5		
3		
3.5		
4		
4.5		
5		
5.5		
6		
6.5		
7		
7.5		
8		
8.5		
9		
9.5		
10		

Heat source removed

name: _____

BLM 3.1b

Analyze Your Data

1. Examine the first 5 minutes of data. Compare the inside and outside temperatures.

What was the greatest temperature difference, and when did it occur?

2. Did the temperature probe outside the box show a rise in temperature? If so, what caused this?

3. Examine the last 5 minutes of data. Compare the inside and outside temperatures.

What was the greatest temperature difference, and when did it occur?

4. Compare the readings for the non-insulated house, and your insulated house. Use the data to explain how insulation changed the way heat flows.

5. By studying the summary of class data, identify the house that reduced heat loss the most.

Why do you think this design was effective?

3.2 Energy Conservation in the Classroom

Time: 2-3 hours

Overview

Ingenious solutions involve creativity. Often, solutions will lie in the area of what is sometimes called "social engineering"—a big term for building teams and relationships within the school. In order for this activity to succeed, teachers will need the support of their colleagues, principal, and caretaker.

In May, June, and September, many classrooms with south and west exposure receive direct sunlight. The heat and glare caused by this direct sunlight makes these classrooms uncomfortable for learning. In this activity, students first observe an exploration of the properties of types of glass. They then explore ways to make such rooms more comfortable by constructing window inserts to diffuse, reflect, or block the sun's rays.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred Specific ■ assess the social and environmental benefits of technologies that reduce heat loss or transfer (e.g., insulated clothing, building insulation, green roofs, energy-efficient buildings) ■ use technological problem-solving skills to identify ways to minimize heat loss ■ use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation
Science and Technology: Interactions in the Environment	■ assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ generate, gather, and organize ideas and information to write for an intended purpose and audience

BLMs

BLM 3.2a
Visual and Thermal
Comfort Survey

BLM 3.2b
Window Survey

BLM 3.2c
Energy Conservation in
the Classroom Summary

Materials

- ◆ EasySense Data Logger
- ◆ infrared sensor
- ◆ Glass Exploration Kit
- ◆ potato chip bags silvered on the inside
- ◆ tracing paper found in gift bags, light fabrics
- ◆ jinx wood and accessories, or other materials that can be used to construct framing
- ◆ gluestick, glue guns, white glue, and tape

Prior Knowledge

- Students should be able to do addition and multiplication using decimals.

Planning Notes

- Identify 1 to 3 teachers in advance who would be willing to participate in this "ingenious solutions" task. Do not reveal to students that you have secured the teachers for this task. Yes, be sneaky. Make it clear that window inserts will be very light, and will not damage any existing frames or window coverings. This is a learning experience.
- Gather the requested materials and read through the activity and its BLMs.
- Plan the student groupings and make copies of the BLMs.

Teaching / Learning Strategies

You might want to structure the activity to support your application for Ecoschools certification. See *GRASP — A Strategy for Developing Lessons for Ecological Literacy* at <http://ecoschools.tdsb.on.ca>.

Improving Classroom Comfort in Hot Weather

**Goal**

To cool down rooms overheated by direct sunlight

**Role**

Interior designer

**Audience**

Teachers and students in overheated rooms

**Scenario**

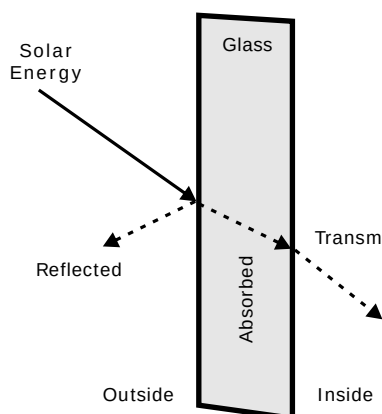
Many students and teachers complain about the conditions in their rooms. Without access to air conditioning, cooling these rooms is difficult because of the amount of direct light that enters the room. Interior designers have been called in to explain to teachers and students what they can do to reduce the discomfort caused by the direct sunlight, while still allowing enough natural light so that artificial lighting is not required. Student designers prepare model frames that control light in different ways. They demonstrate them for teachers and students in hot rooms. Teachers interested in trying an ingenious solution commission the interior designers to scale their model up for use in their room.

**Product**

Students work together in teams to test prototype window coverings.

Part 1

1. Tell students that before they begin their work on improving the heat in the classroom, they are going to explore the properties of various types of glass.
2. Review with students that:
 - sunlight is composed of different types of electromagnetic radiation, some of which reaches the Earth's surface (UV, visible, and infrared)



- forms of energy can be transformed from one type to another (e.g., heat energy to light energy)
- when materials absorb any form of energy, heat energy is generated. Different materials absorb different amounts of light energy.

3. Show students the Glass Exploration Kit and explain that each of the glass plates has different characteristics. Display the following chart and discuss the terms *transmission*, *absorption*, and *reflection*. Focus on one column of data to explain how different the coatings are. For example, Silver 20 transmits 16% of visible light, but IR 70 transmits 72% of visible light.

Film type	Solar energy (including infrared and visible light)			Visible light only (not including infrared)		
	Percent Transmitted	Percent Absorbed	Percent Reflected	Percent Transmitted	Exterior reflectance	Interior reflectance
Bronze 35	21	35	44	35	29	27
Silver 20	12	35	53	16	58	58
IR 70	38	37	25	69	15	15

- Review the classroom energy map made in Section 1, Activity 1.3: Mapping the Classroom and School Ground, and review the roles of conduction, convection, radiation as they pertain to heat loss in the winter.
- Use the wooden board with slats to simulate different window situations, for example, single pane uncoated glass, single pane coated glass, double pane, double pane with specially coated glass. Ask students to predict which arrangement of the glass you choose will admit the most light, and which will admit the most heat.
- Use the Data Logger to measure both the light, and the infrared energy of each setup, and record the data for the class to review and discuss.
- Use different materials with a single pane of uncoated glass to simulate the role that a curtain or other type of window covering has on heat loss in the winter.

Part 2

1. Discuss the role of an interior designer in the construction and renovation industries. Explain why it is worthwhile for an interior designer to understand the importance of natural light, and how light interacts with different materials.
2. Provide time for students to complete BLM 3.2a Visual and Thermal Comfort Survey and BLM 3.2b Window Survey for their own classroom. Invite the caretaker to your room to obtain support in completing the survey.
3. Discuss the basic properties of materials, and their ability to reflect or diffuse light. Consider the advantages and disadvantages of a variety of materials.
4. If time permits, identify stores in the community that have southern and western exposures. Arrange for someone from the store to visit the classroom to discuss visual and thermal comfort in their store, and how they have solved issues related to glare and heat.
5. Construct prototype window coverings using a variety of materials. Test them on the windows of your classroom, or with a flashlight to demonstrate their effectiveness in reflecting or diffusing light.
6. At a staff meeting, announce the nature of this task that you would like to set for your students. Ensure that you have sufficient support before you invite a small group of students to make a brief staff presentation to identify teachers willing to try an ingenious solution in their own rooms. This gives students an opportunity to explain how their window coverings work.
7. Ask small groups of students to arrange visits to the classrooms of the teachers who have volunteered.
8. Ask students to complete BLM 3.2a Visual and Thermal Comfort Survey and BLM 3.2b Windows Survey for the classrooms that they are working with. The support of the caretaker will be highly beneficial, especially to find the dimensions of the windows. Caretakers may have this information so that tall heights need not be measured.

9. Carry out the construction, and “install” the window covering. Think through issues of safety related to the installation of the window coverings. Existing window coverings may serve to hold constructed window coverings in place. Window coverings need not cover the entire window.
10. Ask students to complete BLM 3.2c Energy Conservation in the Classroom Summary.
11. Have students monitor their project and then share and compare their findings as a class. Discuss what worked and what was less successful, and invite students to explain why. Have students prepare a report and presentation to present to the teachers involved, or to the whole school. They might prepare a Powerpoint presentation, demonstration video, photograph display or essay, or illustrated report to summarize the experiment and the results.

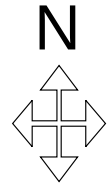
Visual and Thermal Comfort Survey

Name: _____

BLM 3.2a

Draw your classroom floor plan

- windows and doors, carpets, desks or tables, blackboards
- direction and penetration of sunlight at times like 10:00 am, 12:00 pm, and 2:00 pm



Window Survey

Name: _____

BLM 3.2b

Windows

- single pane ☐ double pane ☐
- glazed yes ☐ no ☐
- operable yes ☐ no ☐
- easily opened and closed yes ☐ no ☐ explain: _____
- approximate proportion of window to wall on southern wall: 1/5 ☐ 1/4 ☐ 1/3 ☐ 1/2 ☐
- approximate proportion of window to wall on western wall: 1/5 ☐ 1/4 ☐ 1/3 ☐ 1/2 ☐
- What are the overall conditions of the windows? _____

Window Coverings

- vertical ☐ horizontal ☐ curtains ☐ pull down ☐
- free of clutter yes ☐ no ☐
- easily adjusted yes ☐ no ☐ explain: _____
- What is the condition of the window coverings? _____

Dimensions of window or windows that allow greatest amount of direct light into the classroom
(indicate this on your floor plan)

Energy Conservation in the Classroom Summary

Name: _____

BLM 3.2c

Names of Group Members: _____

Special Materials Used: _____

Diagram of Device

Improvement/Modifications (explain or draw) _____

In what ways could you change or redesign your window coverings?

3.3 Energy Conservation: Selecting a Light Bulb

Time: 1 hour

Overview

This activity allows students to apply their knowledge of the importance of conserving energy through the simple act of choosing a light bulb. Students analyze product data for different bulbs to learn about the factors (size, light output, cost, power consumed, purchase price, disposal, lifetime of bulb) to consider when buying a light bulb. They will calculate the total cost of a light bulb over its lifetime. The true cost is obscured by the way goods are marketed and the way people think about cost. $\text{Total Cost} = \text{Purchase Price} + \text{Cost of Energy Used}$.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred Specific ■ assess the social and environmental benefits of technologies that reduce heat loss or transfer ■ assess the environmental and economic impacts of using conventional and alternative forms of energy
Science and Technology: Interactions in the Environment	■ assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes

BLMs

BLM 3.3a
The Light Bulb Data Sheet

BLM 3.3b
Comparing Bulbs Using
Double Bubble Maps

BLM 3.3c
Comparing Bulbs Using
Venn Diagrams

BLM 3.3d
What's the Best Buy?

BLM 3.3e
Compare Bulbs Using
Number Line Scales

BLM 3.3f
Thinking about Comparing

Planning Notes

- Carefully read through the activity and the BLMs to appreciate the prior mathematics knowledge and skills that your students will need to complete the exercise.
- Prepare copies of the BLMs.

Prior Knowledge

Students should be able to do addition and multiplication using decimals.

Teaching / Learning Strategies

1. Create a context for the activity: *"These days, choosing a light bulb can be overwhelming! There are so many choices. With energy prices going up all the time, you probably want to buy a light bulb that doesn't consume too much energy. Which would you buy? The cheapest? How do you know which bulb is really the cheapest bulb?"*
2. Distribute BLM 3.3a The Light Bulb Data Sheet and ensure that students understand the terms in the chart opposite the pictures.
3. As a class, generate questions from the data sheet.
 - Which kinds of bulbs are the most expensive to purchase?
 - Why are they expensive?
 - Which use the least power?
 - Which last the longest?

Write their answers on the board. Then show students examples of halogen bulbs, incandescent bulbs, and compact fluorescent bulbs. Let them see and hold these bulbs.

4. Show students how to complete a Total Cost calculation for the halogen bulb. See BLM 3.3d What's the Best Buy? Remind them that there are two costs for the consumer — the purchase price (P), and the cost of the energy used over the lifetime of the bulb (E). Ask them to complete their own calculations for the other two bulbs.

As a word equation:

Total Cost = Purchase Price + Cost of Energy Used

Using symbols:

Total Cost = P + E

Materials

- ♦ various types of light bulbs to show the class (halogen, incandescent, compact fluorescent)

To compare the cost, it is important to compare the same amount of time for each bulb. Since the compact fluorescent lamp lasts the longest (about 9000 hours), use it as the standard.

The question then becomes: What is the cost of lighting a room for about 9000 hours with a halogen bulb? Since the halogen bulb lasts 1500 hours, we will need to use 6 halogen bulbs over the 9000 hours. The cost of electricity is found by multiplying the power used (75 Watts=0.075 kW) by the number of hours (9000 hours) by the price of electricity (about 5 cents/kWh = \$0.05/kWh).

Total Cost - halogen bulb

= Purchase Price of Bulbs

= Number of Bulbs x Cost per Bulb

= 6 bulbs x \$8.00/bulb

= \$48.00

= \$81.75

+ Cost of Energy (P + E)

+ Amount of Energy x Cost of Energy

+ (0.075kW x 9000 hours) x \$0.05/kWh

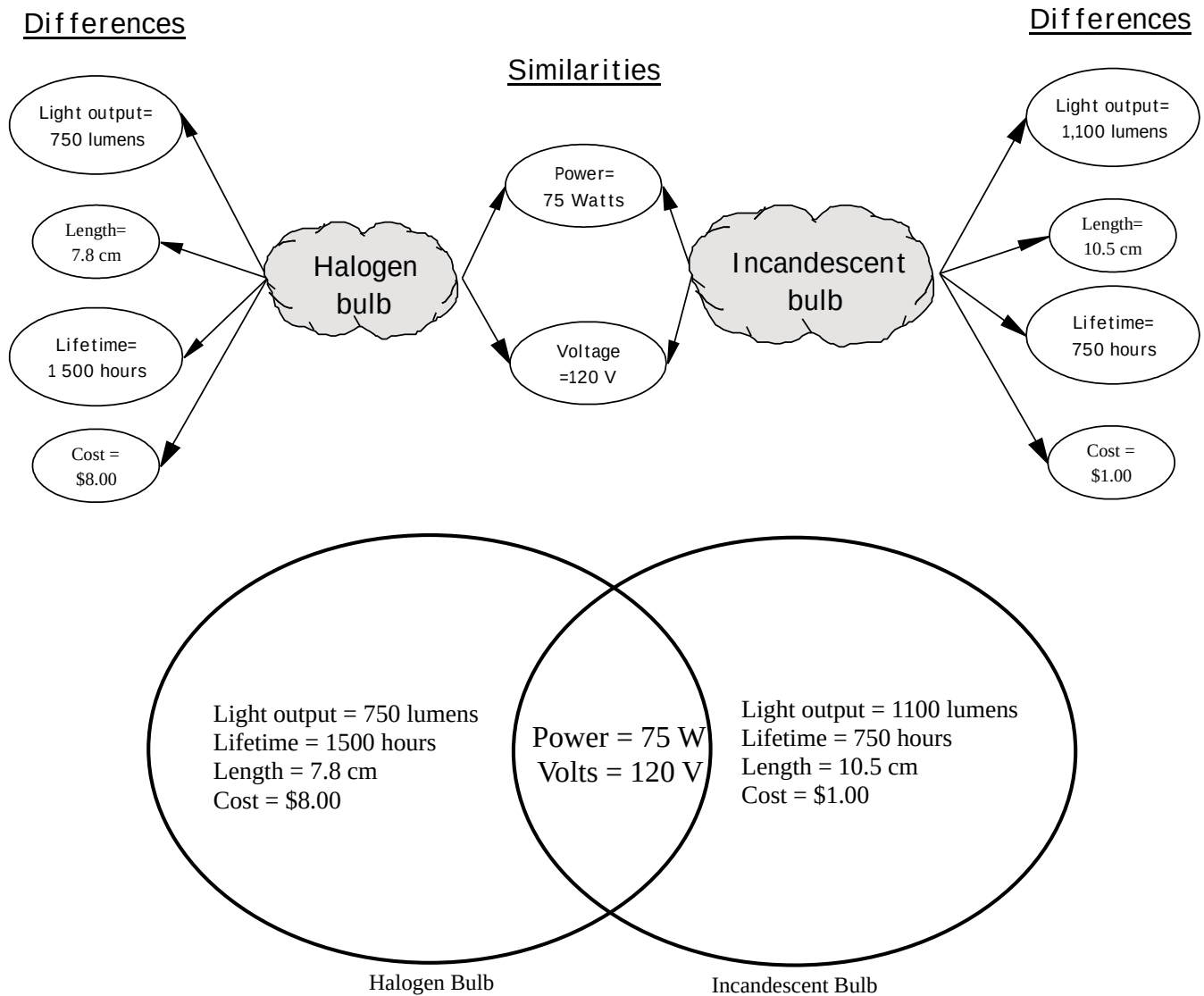
+ \$33.75

All the calculations can be organized in chart form as shown below.

Bulb	Number of bulbs needed	Price per bulb	Price for 9000 hours of light
Halogen	6	\$8.00	\$48.00
Incandescent	12	\$1.00	\$12.00
Compact Fluorescent	1	\$8.00	\$8.00

Energy used	Price of Energy	Energy Cost	Total Cost of Use
0.075 kW x 9000 h	\$0.05 /kWh	\$33.75	\$48.00+\$33.75=\$71.75
0.075 kW x 9000 h	\$0.05 /kWh	\$33.75	\$12.00+\$33.75=\$45.75
0.015 kW x 9000 h	\$0.05 /kWh	\$6.75	\$8.00+\$6.75=\$14.75

- Compare the halogen bulb and the incandescent bulb with your students to model your thinking, and to teach, or review with students, how to use a compare/contrast graphic organizer.
- Remind students that the typical product label may not tell the consumer what the total cost of an electrical device will be over its entire life. Ask students “*Why not?*” (Prices of electricity are not the same in all provinces, and sometimes the price of energy rises, so the total cost of use is often left to the consumer to find out.)
- Ask students to complete one of the other comparisons: Halogen-Compact Fluorescent and Incandescent-Compact Fluorescent. Consider supplying them with either a double bubble map (BLM 3.3b) or a Venn Diagram (BLM 3.3c). Samples on the next page have been completed for teacher’s information. They can also use BLM 3.3d to calculate a comparison costs.



8. Provide time for students to use number line scales to weigh the factors for each bulb. See BLM 3.3e Compare Bulbs Using Number Line Scales for a sample. Some of the scales increase when read from left to right. Some of them decrease. In all cases, values on the left of the scale indicate a poorer choice than values on the right.
9. After students have analyzed the light bulbs in several different ways, ask them to think about which method of comparison was: easiest, most accurate, quickest, or most likely to be used in a store. This part of inquiry—metathinking—is very important. We have to teach students to reflect on how different methods have worked well and why.

The Light Bulb Data Sheet

name: _____

BLM 3.3a

The packaging on light bulbs usually has quite a bit of information.
The information below was taken from the packages of different kinds of light bulbs.

Study the information carefully, to:

- Compare the halogen bulb with the incandescent bulb.
- Compare the incandescent bulb with the compact fluorescent bulb.



1.
Brightness 750 lumens
Power Used: 75 watts
Average Lifetime: 1500 hours
Volts: 120 V
Length: 7.8 cm
Purchase Price: \$8.00 Each



2.
Brightness 1100 lumens
Power Used: 75 watts
Average Lifetime 750 hours
Volts: 120 V
Length: 10.5 cm
Purchase Price: \$1.00 Each

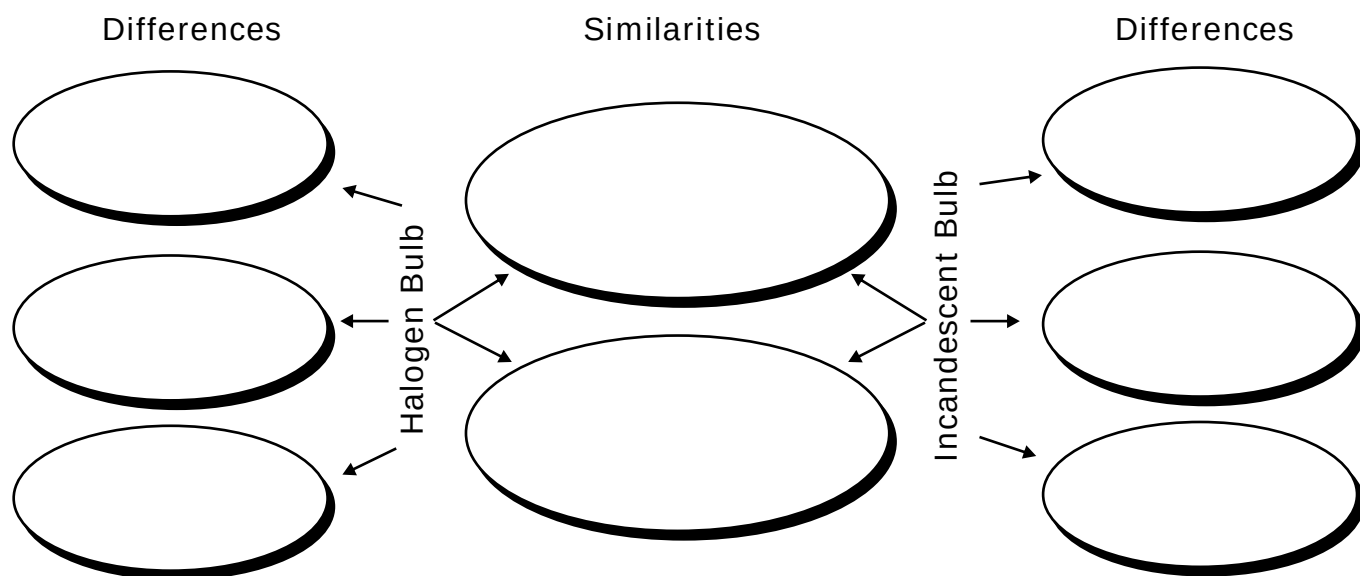
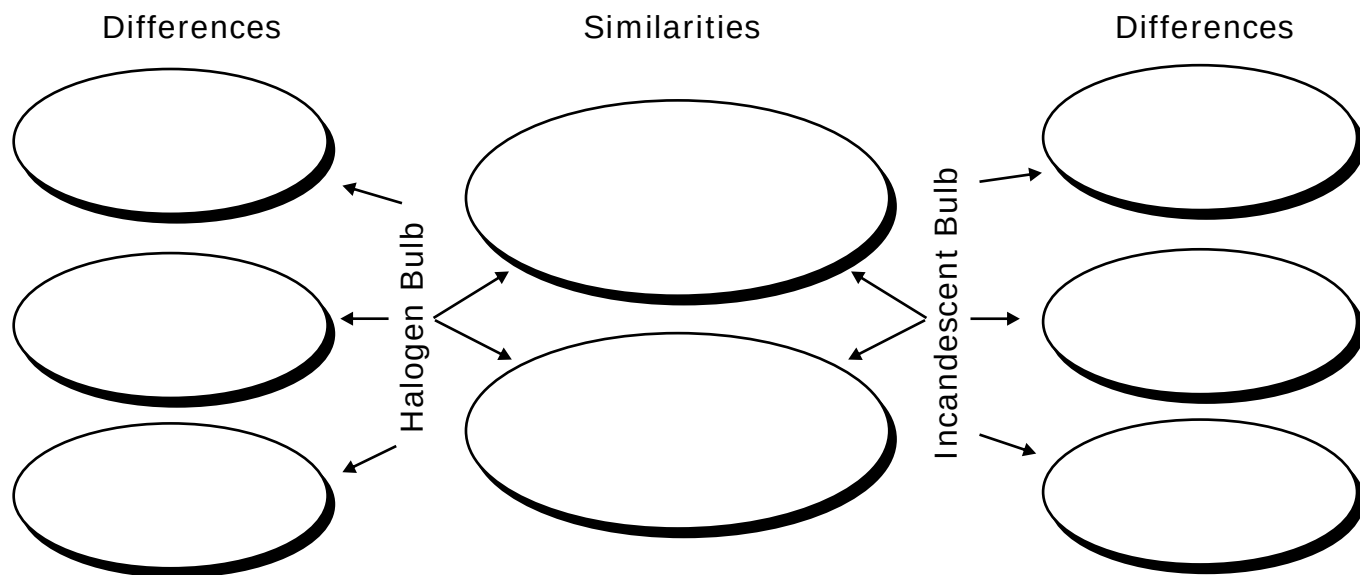


3.
Brightness 1150 lumens
Power Used: 15 watts
Average Lifetime: 9000 hours
Volts: 120 V
Length: 15.5 cm
Purchase Price: \$8.00 Each

Comparing Bulbs Using Double Bubble Maps

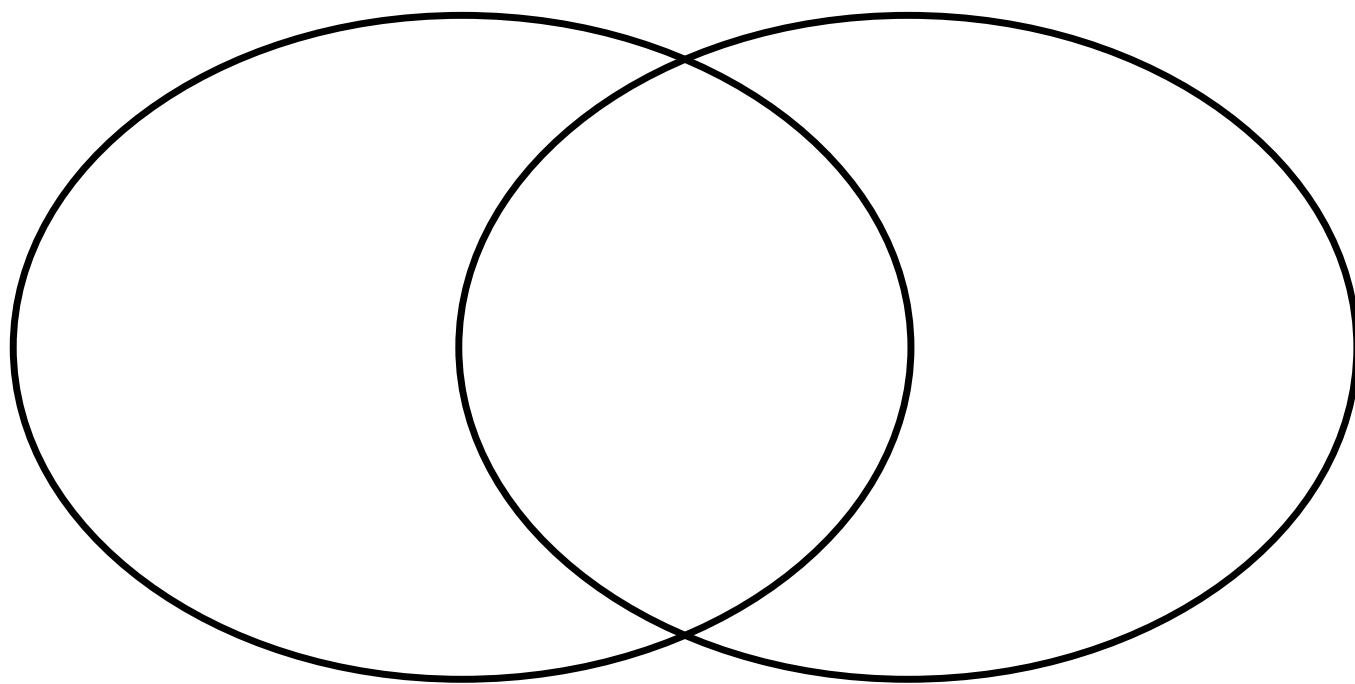
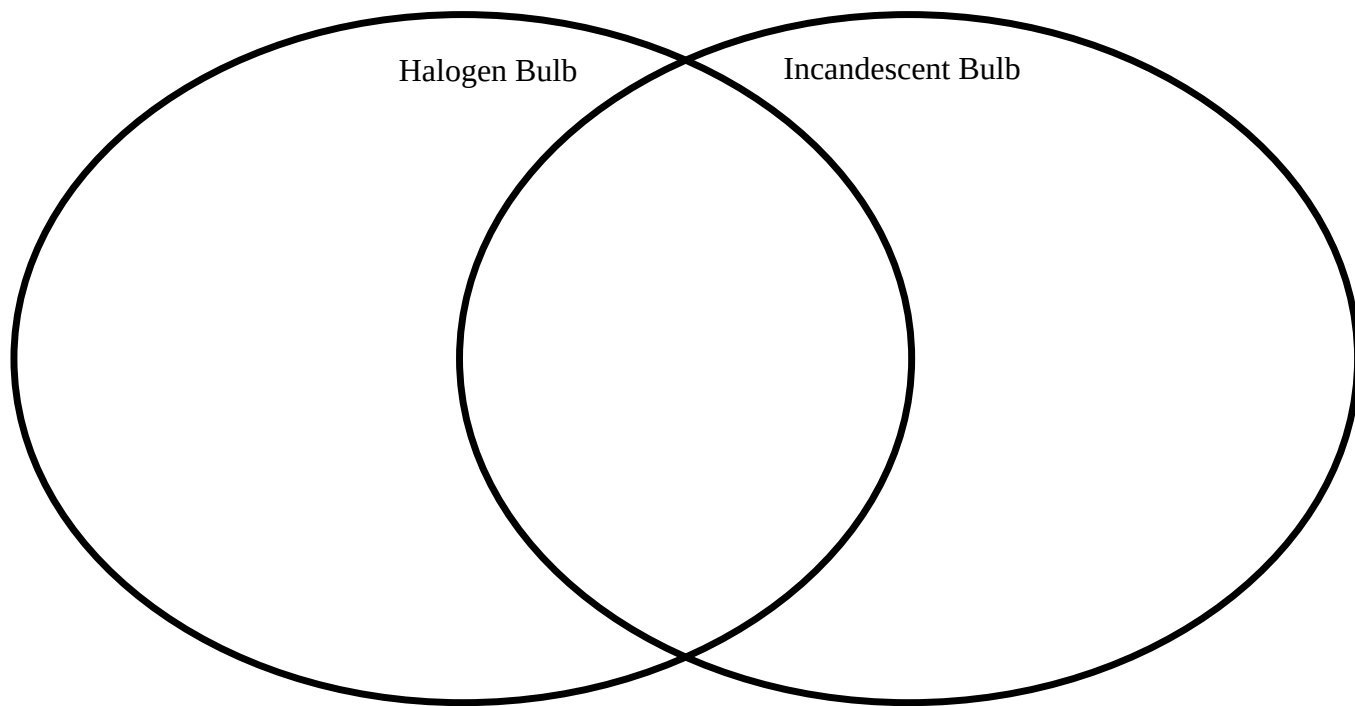
Name: _____

BLM 3.3b



Comparing Bulbs Using Venn Diagrams

Name: _____

BLM 3.3c

What's the Best Buy?

Comparing Bulbs by Calculating Total Cost of Use

Name: _____

BLM 3.3d

1. Calculate the purchase price of each bulb for 9000 hours of light. The first one is done.

Bulb	Number of bulbs needed for 9000 hours of light	Price per bulb	Purchase price for 9000 hours of light
Halogen	6	\$8.00	\$48.00
Incandescent			
Compact Fluorescent			

2. Calculate the energy cost for each bulb. To fill in the first column, convert power in watts to power in kW by dividing the power by 1000. Then, multiply it by 9000 hours. Finally, multiply by the cost of energy which is usually written in dollars per kilowatt hour (or \$/kWh). The first row is done for you.

Bulb	Energy used	Price of Energy	Energy Cost
Halogen	0.075 kW x 9000 h	\$0.05 /kWh	\$33.75

3. Now calculate the total cost of use of each bulb using the formula below:

Total Cost = Purchase Price + Cost of Energy Used

Halogen $\$48.00 + \$33.75 = \$81.75$

Incandescent

Compact Fluorescent

Compare Bulbs Using Number Line Scales

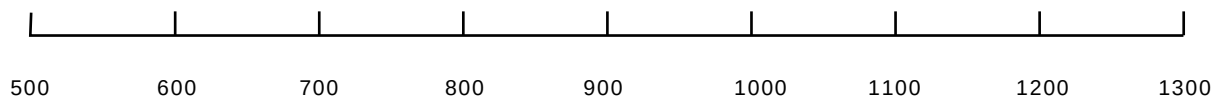
Name: _____

BLM 3.3e

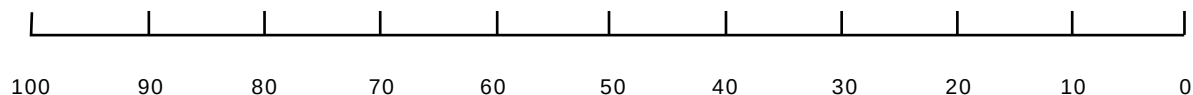
You can use number line scales to help decide which kind of light bulb to buy.
Make a symbol for each bulb type and draw it in the proper locations.

← WORSE BETTER →

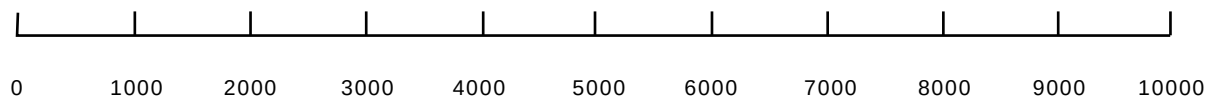
Brightness (Lumens)



Power Used (Watts)



Average Lifetime (Hours)



Purchase Price (\$)



Thinking about Comparing

Name: _____

BLM 3.3f

1. Think about which method of comparison was: easiest, most difficult, or most useful.

This part of inquiry—thinking about what worked best for you—is very important.

2. Explain why it isn't always the best idea to buy the "cheapest" electrical device.

3. Why might some people ignore the cost of electricity when making a decision to buy an electrical device such as a light bulb?

4. In your opinion, are electrical products labelled well enough to help consumers make wise decisions?

5. What would you recommend to make it easier for customers to see the "true" cost of each light bulb?

3.4 Using the EcoSchools Program

Time: 2-3 hours

Overview

One goal of the EcoSchools program is to highlight the environmental impact of our schools and provide schools with the tools to reduce this impact. The Energy Conservation EcoReview was developed to support this goal.

Curriculum Connections

Subject Area	Expectations
Science and Technology: Heat in the Environment	Overall ■ assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment ■ investigate ways in which heat changes substances, and describe how heat is transferred ■ demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within the earth's systems Specific ■ assess the social and environmental benefits of technologies that reduce heat loss or transfer ■ assess the environmental and economic impacts of using conventional and alternative forms of energy
Science and Technology: Interactions in the Environment	■ assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts
Geography	■ describe positive and negative ways in which human activity can affect resource sustainability and the health of the environment
Language Arts	■ read and demonstrate an understanding of texts ■ use speaking skills and strategies to communicate for a variety of purposes ■ generate, gather, and organize ideas and information to write for an intended purpose and audience ■ create a variety of media texts for different purposes and audiences

BLM 3.4

Reduce Impact on the Environment.

Energy: Conservation and Efficiency

Materials

- ◆ EcoSchools
Certification Guide and Planner 2009/10
- ◆ EcoSchools
Certification Toolkit 2009/10

Planning Notes

- Consult your school's environment club advisor, or EcoTeam, to see if anyone in the school has completed the EcoSchools Energy Conservation EcoReview. If yes, obtain a copy of the EcoReview. If not, prepare a blank copy to work through with your students.
- Schedule time with the school caretaker to take students on their energy tour of the school.
- Make displays or copies of the BLMs and organize student groupings.

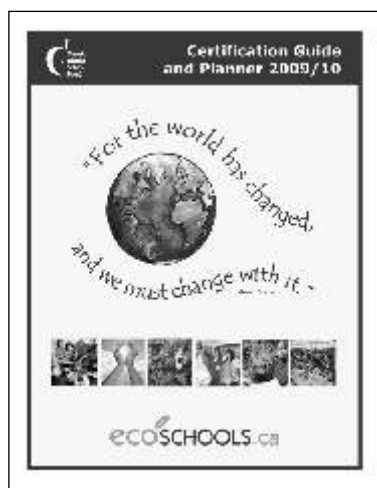
Background

EcoSchools is a school greening program with a very broad scope. It addresses what is taught, how we run our schools, and how we design and use our schools grounds. Its central focus is supporting students and staff in caring for and protecting the environment where they spend so many hours every week. EcoSchools asks us to examine the decisions we make in our schools, inside and out — from modifying practices in our classrooms, offices, and boiler rooms to designing the school ground as a place for healthy, enriched learning.

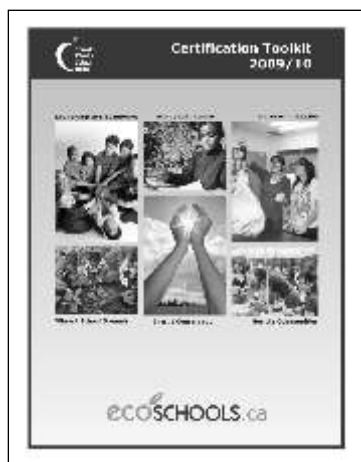
It's a big job. School Services (curriculum), Facility Services (school operations) and Purchasing departments all devote staff time to helping schools move toward more environmentally aware and sound practices.

At the school level, the EcoSchools program is spearheaded by an EcoTeam made up of representatives from all areas of school life — from principal and caretaker to teachers, parents/guardians, and students.

The 2009/10 *EcoSchools Certification Guide and Planner* can help you complete the online application form and is an excellent planning tool for your program. It is especially helpful for schools new to the program, providing a simple way to explain the different EcoSchools action categories, and to decide where to concentrate your school's environmental efforts.



The new EcoSchools *Certification Toolkit* brings together in one place all of the “tools” that schools require to help them access the services, materials, and equipment needed to achieve their goals. The toolkit is closely aligned with the EcoSchools *Certification Guide and Planner* and the new online application form.



Teaching / Learning Strategies

1. Review BLM 3.4e: Energy Conservation EcoReview with the class. Place students into teams to address the three major energy impacts of your school:
 - a. Natural gas consumption
 - b. Electricity consumption
 - c. Embedded energy or resources consumed
2. Discuss each in turn to identify the impacts on the environment. Remind students that:
 - a. Natural gas is a non-renewable fuel source, and that its consumption has local and global impacts.
 - b. Electricity is generated from nuclear, hydro, and coal, and that its consumption has varied local and global impacts.
 - c. Resources consumed at the school require energy of extraction, production and disposal. Consumption of resources, both renewable and non-renewable, has varied local and global impacts.
3. Have each group develop a campaign to reduce these impacts. Take advantage of opportunities to integrate language studies and data management into the students' work. Provide each group of students with one of the monitoring posters, described on page 149.

Some ideas are:

- create a brochure, leaflet, bookmark, or fridge magnet to hand out to the school community
- create a series of “radio ads” for morning announcements
- create a page linked to the school's website
- create posters for display in the school
- create a Powerpoint presentation, video, or music video
- create a T-shirt design
- create a school calendar

4. Collaborate with your school's caretaker to take students on an energy tour of the school. Help students understand how the school receives natural gas and electricity. What systems are in place to deliver these energy sources to the school? What are the impacts of these delivery systems (think of the land impacts of long-distance pipelines and hydro corridors).
5. Collaborate with your EcoTeam to ensure that your class's work is included by the EcoTeam in the school's application for EcoSchools certification.

Education for the Environment: Monitoring Our Use of Finite Resources

To download a pdf of these posters, visit
ecoschools.ca > *certification toolkit*.

To order print copies in colour see the order form on page 4 of the *EcoSchools Certification Toolkit*.

It is said that you can only improve what you can measure. The three monitoring charts (shown below) give students a system for checking and recording classroom recycling and energy conservation practices throughout the year. These posters provide a way to gather primary data for authentic data management lessons. And of course, they are a great way to communicate progress (or slippage!) visually to the whole school! These posters come highly recommended from teachers and students who use them (they are suitable for both elementary and secondary schools). Attractive colour copies are available on 11" x 17" sheets. See the Order Form on page xx.

Keep the Heat In.
Conserve fossil fuels.
Use this monitoring poster to highlight our dependence on limited and CO₂-producing fossil fuels. Closing the blinds makes a difference!

Let the Sunlight In.
Conserve electrical energy. We are still burning coal to produce light in our classrooms. Use this poster to remind people to let free sunlight do the job whenever possible!

Save Our Resources.
Maximize resource use.
Use this monitoring poster to learn how well your school is keeping recyclables like paper, cans, and bottles from reaching landfill.

Keep The HEAT In Close blinds & curtains at the end of the day.

Legend: ☐ All Blinds Closed ☐ Some Blinds Closed ☐ No Blinds Closed

ecoSCHOOLS.ca

Let The Sunlight In CONSERVE ELECTRICAL ENERGY Open window coverings in the morning and turn off the lights.

Legend: ☐ All Lights Off ☐ Some Lights Off ☐ No Lights Off

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Save Our Resources MAXIMIZE RESOURCE USE Keep resources like paper, cans and bottles out of the garbage.

Legend: ☐ NO recyclables in waste basket ☐ SOME recyclables in waste basket ☐ MANY recyclables in waste basket

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2.1 Reduce Impact on the Environment

Energy: Conservation and Efficiency

BLM 3.4

GUIDING QUESTION: Does your school implement daily routines and operational practices that significantly reduce its impact on the environment? ◆ Hold this question in mind as you rate your performance. ■ Initial ▲ Final		No evidence	Emerging	Credible	Accomplished	Comprehensive
Team Self-Assessment and Documentation  (70% this year)		0	1	2	3	4
◆ Reducing energy use in instructional areas						
2.1.1	Are portable electric heaters used only as a short-term emergency measure with the principal's approval until heating problems are resolved?					
◆ Reducing energy use across the whole school						
2.1.2	To what extent is lighting used only when necessary (e.g., not in stairwells and corridors with extensive natural lighting, outside lights adjusted seasonally and turned off during daylight hours and at night after caretakers leave the school)?					
2.1.3	Has your school found solutions to reduce energy use in over-lit areas in all parts of the school (e.g., implement and maintain de-lamping, use task lighting where appropriate)?					
2.1.4	Are electrical energy losses kept to a minimum throughout the school (e.g., standby power losses from TVs, DVDs, VCRs, modems, and adaptors; evening and weekend electricity waste from vending machines)?					
2.1.5	 Does your school have an appliance consolidation plan to save energy by using less equipment (e.g., replace a large number of "bar" refrigerators with fewer standard-sized Energy Star refrigerators, reduce number of computer printers through networking)?					
2.1.6	To what extent is heat loss in the winter and heat gain in the summer reduced to a minimum (e.g., keep outside doors closed, close blinds/curtains at the end of the day, clear vents on walls and/or window sills to reduce energy needed for proper ventilation)?					
2.1.7	 To what extent has your school purchased energy efficient devices and machines (e.g. LCD monitors, duplex [double-sided] printers, Energy Star refrigerators, dishwashers, clothes dryers, compact fluorescent bulbs)?					
◆ Conserving energy through specialized practices of caretakers						
2.1.8	Are regular inspections of the building conducted and notifications submitted as required (e.g., fix broken valves, check roof vent seals, dampers, louvers, filters for school and portables, motors, compressors, thermostats, window and door seals as indicated in the TDSB Caretaking Handbook)?					
2.1.9	Does the EcoTeam work collaboratively to review the building automation system (BAS) schedules for instructional and non-instructional days (to ensure that the BAS is used to reduce the school's energy consumption as much as possible—the BAS is set to automatic mode, the BAS schedules equipment off in zones when heating/cooling is not needed)?					
Performance Indicator (0% this year)		0	1	2	3	4
2.1.10	Is there an overall pattern of continued decrease in the school's electricity consumption year after year? (level 1 = 5%; level 2 = 10%; level 3 = 15%; level 4 = 20%)					
School Visit "look-fors" (30% this year)		0	1	2	3	4
2.1.11	Lighting is used only when necessary (e.g., lights are turned off when adequate light is available from the sun, or when rooms are not being used).					
2.1.12	Year-long monitoring of lights-off is recorded by students.					

The 11" x 17" planning version of this EcoReview is in the Portfolio Binder.

Greater Toronto Area - a Surface Temperature Map 2002-08-10

Several copies of this map are included in the TDSB's Science and Technology Kit called Heat in the Environment. This temperature map is used in Activity 2.4: The Urban Heat Island Effect, on page 87.

